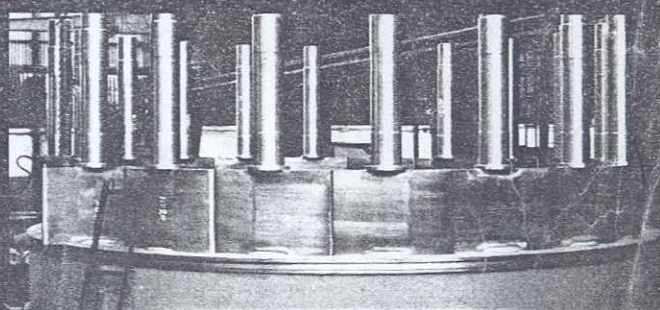
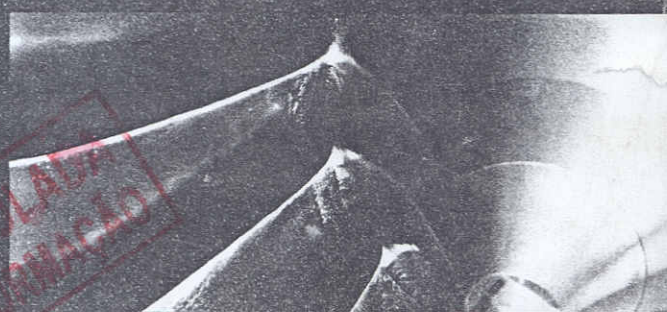
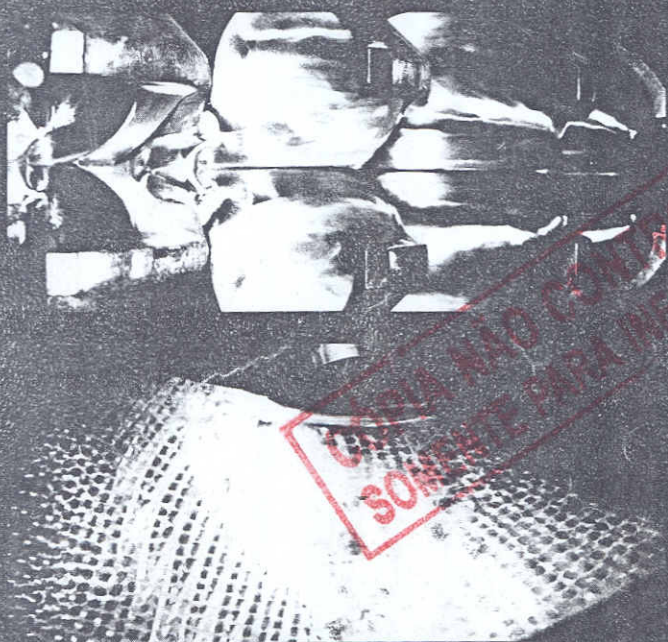


CAHIER DES CHARGES

CCH 70-3

SPECIFICATION FOR INSPECTION OF STEEL CASTINGS FOR HYDRAULIC MACHINES



Cópia não controlada
somente para informação

**CÓPIA NÃO CONTROLADA
SOMENTE PARA INFORMAÇÃO**

CCH 70-3

GRUPE D'ÉTUDE

CAHIER DES CHARGES HYDRAULIQUES

LIST OF "PARTNER FIRMS"

having subscribed to the third edition (CCH 70-3)

(Statement at mid-December 1996)

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09-96	SULZER - DE PRETTO / ESCHER WYSS	Schio	(I)

EDITION 3 (June 1996)

(Annuls and replaces the Edition 2 of June 1979)

SUMMARY

The present SPECIFICATION comprises :

Introduction			Page	3
6 indicative specimens of the QUALITY SHEET, with its addition				7
5 technical specifications :				
- for general receiving requirements	GE 70-3	General		19
- for dye penetrant inspection	PT 70-3	Penetrant Testing		29
- for magnetic particle inspection	MT 70-3	Magnetic Testing		37
- for ultrasonic inspection	UT 70-3	Ultrasonic Testing		43
- for radiographic inspection	RT 70-3	Radiographic Testing		71

CDU - 669.14 : 621.224 / 620.1 (083.7) = 20

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INTRODUCTION

1 - PREAMBLE TO THE THIRD EDITION

Nov 1971	CCH 70-1	The first edition was prepared on the initiative of a STUDY GROUP (Groupe d'Etude) formed by several European Designers and Founders .
June 1979	CCH 70-2	The second edition took into account the accumulated experiences during the first years of use.
June 1996	CCH 70-3	The third edition is adapted: -to the actual principles of the QUALITY organisation, -to the frequent practice of finishing the parts in the shops of a firm other than the Designer , -to the latest developments of non destructive inspections.

THE STUDY GROUP is duly constituted as "A non profit Organization" with articles of association. For this third edition, it gathers 3 **Founders**, 3 **Designers**, from Europe and North America and 1 **Independent control organization** as well as several technical consultants.

2 - TERMINOLOGY

2.1 ASSOCIATES

Throughout this SPECIFICATION, only the following four designations will be used to refer to the different parties involved.

CUSTOMER	refers to the buyer/user of the hydraulic machine or his representative.
DESIGNER	refers to the designer of the hydraulic machine or his representative.
FOUNDER	refers to the party responsible for the metallurgical realization of a casting.
MANUFACTURER	refers to the party performing the various phases of manufacturing leading to the completion of a component of the hydraulic machine or his representative.

Subject to technical or economic circumstances as well as contract conditions, the **Manufacturer** may be mistaken for either the **Designer** or the **Founder** or yet a third party (FIRM) separate from either of the other two.

It will be the responsibility of the issuer of **Quality Sheets (QS)** to clearly complete those sheets, so as to define without ambiguity the place of examination and consequently the state of advancement required for the various controls prescribed.

2.2 TYPES OF MATERIALS

The present specification applies to cast steels:

- Ferritic non alloyed or low alloyed steels
- Martensitic corrosion resistant steels Cr-Ni-(Mo), with martensitic transformation after annealing with 10 to 30% austenite (13-4, 17-4 for example)
- Austeno-ferritic (Duplex) corrosion resistant steels Cr-Ni-(Mo), without structural transformation: 35 to 65% austenite, 35 to 65% ferrite.
- Austenitic corrosion resistant steels Cr-Ni-(Mo), without structural transformation: 85 to 95% austenite, 5 to 15% ferrite.

The **Designer** may have to produce several **Quality Sheets (QS)** for some complex items (welded assemblies). In this case each party will have to be aware of several **Quality Sheets** produced.

The **Quality sheets** should be part of:

- The **Designer's** quotation to his **Customer**,
- The **Designer's** inquiry to the **Founder** consulted and to the **Manufacturer** consulted,
- The **Designer's** order to the chosen **Founder**,
- The **Designer's** or the **Founder's** order to the **Manufacturer**.

They will be legally valid in case of divergence with other documents. They particularly define:

- The authority or authorities responsible for reception,
- The standards used as a reference,
- The specifications to be applied for verification of chemical composition and mechanical properties,
- The break down of the casting into different areas,
- The places where the different inspections have to be carried out,
- The surface quality required for each area of the casting,
- The non-destructive testing method to be applied for checking the soundness of each casting area, as well as the extent of the inspection (e.g. 100% inspection or spot checking),
- The acceptance criteria for the required inspections
- Specific requirements for certain manufacturing and inspection operations.

No other inspections exceeding those defined may be required without mutual agreement of the interested parties. If complementary inspections are decided by such an agreement they will only have an informative value or will be the subject of an amendment to the order.

If a given area should be inspected by spot checking only, the conditions will be defined after agreement between the parties.

If a confirmative radiographic inspection is foreseen, radiography will only be carried out in case the results obtained by ultrasonics do not conform with the specified criteria and thus do not permit an evaluation of the acceptability of the indication. The decision to repair or to perform a radiographic inspection for confirmation is left to the **Founder** (see technical specification UT 70-3).

The non destructive inspections required by the **Quality Sheet (QS)** as having to be carried out by the **Manufacturer** or **Designer** on the finished part, engage the responsibility of the **Founder**; thus informed about the **Designer's** intentions and backed by his experience, the **Founder** will take the necessary measures to avoid -as much as possible - any possible failure of his supply in this subsequent state, by having recourse to manufacturing precautionary measures and to preliminary inspections corresponding to the **Designer's** requirements (see technical specification GE 70-3).

2.3 QUALITY SHEETS

The **Quality sheet (QS)** is a document which contains all the arrangements relative to the technology and the control which are included in the agreement at time of placing an order for a hydraulic component according to CCH 70-3.

3 - OBJECTIVE

The objective of this CCH 70-3 is to give an unequivocal definition of the technical and general supply conditions for cast steel components used in hydraulic machines. It is therefore applicable for all items having at least one element in cast steel and constituting one part of a hydraulic machine.

To meet this objective, it defines especially all the inspection methods, the application procedures and the acceptance criteria to be considered during receiving inspections in the **Foundry** as well as in the **Manufacturer's** works.

Note : It is recommended that the **Designer** includes one copy of the CCH 70-3 in the technical file handed to the Powerplant upon delivery of the machine.

4 - COMMENTS ON QUALITY SHEETS

It is of great importance to distinguish the **Quality sheets (QS.)** enclosed in this specification, (pages 7 to 18) identified as "**SPECIMEN**" and those **Quality sheets** which will be filled in by the **Designer** for each casting considered to be important.

The first mentioned are only fictitious examples for illustration.

The indications given are in no way intended to serve as a rule, neither for the mechanical testing conditions nor for the choice of the non-destructive testing method to be applied.

The highly stressed areas are indicated by two concentric circles. Example: 

The squares hatched or cross-hatched in blue, show different cases of inspection restriction which may occur:

The squares with cross-hatched shading indicate that the type of inspection in question is very difficult or virtually impossible on the areas concerned because of limited-accessibility, incompatibility of shape and method or other reasons;

Squares with single hatched shading represent unusual inspections due to diverse circumstances.

Blank squares show those cases where the inspections are feasible but considered not to be necessary for the casting to be inspected.

The seconds mentioned specify the purchase conditions and acceptance standards; they have to be filled in by the **Designer** with a maximum of objectiveness with regard to the contract with his **Customer**. These forms will not only determine the casting quality, but also influence the prices.

Indeed, the quality level required involves a definite manufacturing routine and special precautions to be taken by the **Founder**, the **Manufacturer** or the **Designer**.

5 - CORRELATION BETWEEN THE QUALITY SHEET AND THE TECHNICAL INSPECTION SPECIFICATIONS

The requirements to be specified by the **Designer** in the **Quality Sheet (QS)** are identified by the symbol ♦ in the right hand margin of the various paragraphs defining the requirements (GE, PT, MT, UT, RT). These requirements will be indicated as well in the check-list in the back of the **Quality Sheet (QS)** or appended to the **Quality Sheet (QS)**.

QUALITY SHEET

Nr QS - 0010

CCH 70-3

Power plant SALTO GRANDE
 Drawings Nr 68981 and 4803
 Customer / Country «V»
 Designer «X»
 Founder «Y»
 Manufacturer «Z»

Quantity and designation 3 PELTON RUNNERS
 Unitary weight (finished casting) 19.000 kg
 Inquiry Nr 3542 dated 18.11.95
 Order Nr 120711 dated 15.02.96
 Inspection at F's works by «V» + «X» (b)
 Inspection at M's works by «V» (b)

CHARACTERISTICS OF MATERIAL

Designation : G - X5 Cr Ni 13.4

According to standard : analogic DIN 17445

Values or ranges required	Chemical	C %	Mn %	Si %	Cr %	Ni %	Mo %	S %	P %	S+P %	
		≤ 0.05	≤ 1.5	≤ 1.0	12.0 / 13.5	3.5 / 5.0	≤ 0.7	≤ 0.015	≤ 0.025	≤ 0.030	
	Mechanical properties	Rm MPa	Rp0.2 MPa	A5 %	Z %	CVN (e) J at t °C	H	Inspection certificate			
		730 / 840	540 / 710	≥ 15		≥ 90 0°	240 / 300	according to EN 10204			

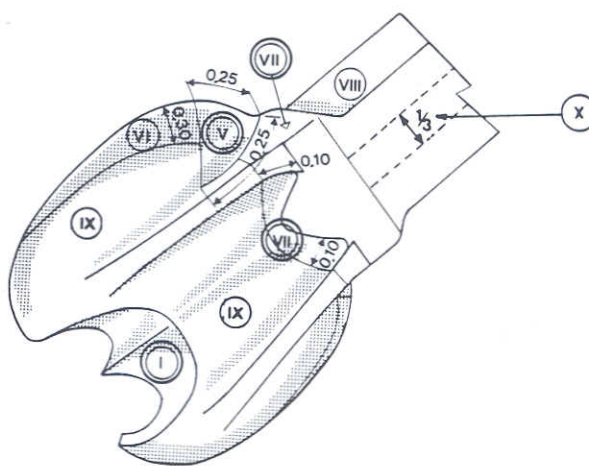
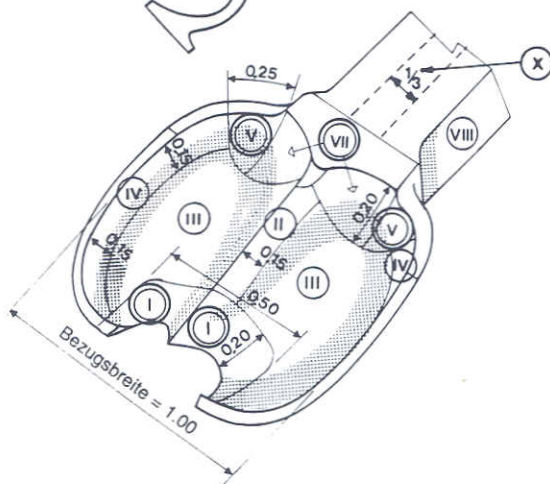
NON DESTRUCTIVE TESTINGS

The Designer's requirements are indicated in the table below by **X** (or by QL, QP, SL according to DT 70-3 § 1.4.2)

Technical Specifications CCH 70 - 3	Areas (a)	I		II		III		IV		V		VI		VII		VIII		IX		X	
	Inspections (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
	Surface quality (c)	N9	N6	N9	N6	N9	N7	N9	N7	N9	N7	N9	N6	N9	N6	N10	N8	N10	N10	-	-
	PT (d)		X		X		X		X		X		X		X		X		X		X
	MT (d)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	UT (d)	X												X		X				X	
	RT (d)	X																			
	Acceptance criterias on :																				
Casting	PT	§ 4.3	1	2	3	2	1	2	2	2	2	2	1	1	2	2	2	2			
	MT	§ 6	2	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2			
	UT	§ 1.7 / 2.7	2							2				1	2					3	
	RT	§ 11.1	A2 B2 C2							A2 B2 C2				A2 B2 C1	A2 B2 C2					A3 B2 C2	
	Repairs	UT	§ 1.9 / 2.7																		
	RT	§ 11.2																			

SKETCH/DEFINING THE AREAS

Reference dimension for the areas : 720 mm



- (a) See sketch
 (b) F=Founder M=Manufacturer
 (c) See back
 (d) According to spec. CCH 70-3
 (e) Delete where not applicable
 (f) See casting's drawing

Name and signed
 Dated

Established by

Checked by

Approved by

"Designer"

«X X X X X»

ADDITIONS TO QUALITY SHEET

Nr QS - 0010

CCH 70-3

MECHANICAL TESTS at the FOUNDER'S WORKS, according to GE 70-3, § 2.2

(★) = Delete where not applicable

«Cast-on» test-coupons. (★)

~~«Separately cast» test blocs. (★)~~

Number of test-coupons : (★)

2

per casting,

/

~~per lot of castings coming from the same heat,~~

i.e. :

1

to be tested and

1

for retest.

Position and dimensions of the test-coupons are given by the Designer, either on the drawing or on the sketch of the Q.S. If nothing has been specified, the choice will be left to the Founder.

Before removal, the test-coupons will be stamped and identified by the Founder in the presence of : «V» and/or «X»

Stress relieving heat treatment : (★) - with test-coupons reattached on the castings.
- ~~simulated stress relieving of test-coupons.~~

Test specimens :

Each test-coupon shall give

1

tension-test specimen(s) and

2 x 3

impact-test specimens.

Standard(s) :

Nr DIN 50115 , DIN 50125

Chapter	§	CHECK-LIST of other requirements from DESIGNER, according to the symbols ♦ in margin (see Introduction, § 5)	Annex Nr	Page
GE	1.4	Conditions of heat treatments are to be communicated to the Designer.	A	3
GE	1.5	Procedure for reception specified by the Customer (advance notice, aso.)	B	3
GE	2.1	Check-analysis on casting, if required.		
GE	2.2.1.3	Hardness test on casting, if required.		
GE	3.1	Special surface qualities (possible code).		
GE	3.3	Pressure test, if required.		
GE	3.4	Runner balancing : requirements.	C	4
GE	4.1	Dimensional inspections and tolerances.	D	4
GE	5.1.2.1	Other definition of «major» repairs.		
GE	5.1.2.2	Designation of «highly stressed» areas. <i>see sketch</i>	-	-
GE	5.1.3	Other acceptance criterias in excavations (welding preparation).		
GE	5.1.4	Other convention relative to quality of repair weldings.		
GE	5.2.3	Designation of excavations to be submitted for weld approval.	E	4
GE	5.3.3	Mutual agreement regarding repartition of cost of repairs.		
GE	7.2	Conditions and duration of guarantee granted by the Designer.	F	5
PT	3	Other method and process, if required.		
MT	3.1.2	Process of magnetization required or particular procedure.		
MT	4.3	Type of agent for detection, if required. <i>liquid ink / fluorescent light.</i>	-	-
MT	7.2	Admissible residual magnetization, if required. <i>max 0,6 kA/m (8 Oe)</i>	-	-
UT	0.2	Transverse wave examination, if specified.		
UT	1.2	Method to be use : CAD or AVG. (★)	-	-
UT	1.3.2	Type of probe to be use.		
UT	1.3.4	Special type of couplant, if required.		
UT	1.4.2	Definition and location of a network, if required.		
UT	1.9	Possible supplementary inspections on «major» repairs.		
UT	2.2	Method to be use : CAD or AVG. (★)	-	-
UT	2.4.2	Other limits than proposed by figures 7 to 11.		
RT	2	Other specific procedure, if required.		
RT	10.1	Type of IQI, if required.		
RT	10.3	Duration for archiving of films.	G	5
RT	11.2	<i>Only if UT in not clear and RT possible. (geometrie)</i>	-	-
GE	2.2.1	<i>Rp0,2 / Rm < 0,85</i>	-	-
				2 / 5

Anlage SCHWARZSEE
 Zeichnungen Nr 258745
 Kunde / Land «V»
 Konstrukteur «X»
 Giesser «Y»
 Hersteller (?) = «Z»

Anzahl und Bezeichnung 1 FRANCISLAUFRAD
 Einzel-Fertigsgewicht 14.600 kg
 Anfrage - Nr 6540 vom 11-05-96
 Bestellung - Nr vom
 Abnahme beim G durch «W» + «X» + «Z» (b)
 Abnahme beim H durch «V» + «W» + «X» (b)

MATERIALEIGENSCHAFTEN

Bezeichnung : 6 - X 5 Cr Ni Mo 165gemäss Norm : W - Nr 1.4405

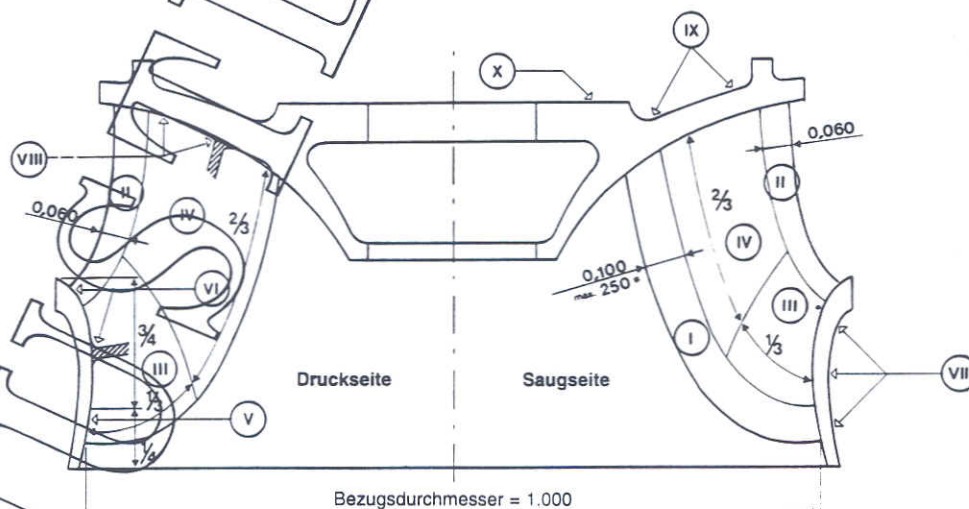
Vorgeschriebene Grenzwerthe	Chemische Zusammensetzung	C %	Mn %	Si %	Cr %	Ni %	Mo %	S %	P %	S+P %	
		≤ 0.07	~ 0.6	~ 0.6	~ 15.5	~ 5.5	~ 1.0	≤ 0.015	≤ 0.025	≤ 0.030	
Mechanische Eigenschaften	Rm MPa	Rp 0.2 MPa	A5 %	Z %	CVN ^(e) CUN	bei °C	H	Abnahmeprüfzeugnis gemäss <u>DIN 50049-3.2 c</u>			
	≥ 760	≥ 540	≥ 15		≥ 50	+ 20°					

ZERSTÖRUNGSFREIE PRÜFUNGEN

Die vorschritten des Konstrukteurs sind nachstehend mit **X** (oder mit **QL**, **QP**, **SL** gemäss UT 70-3 § 1.4.2)

Technische Spezifikationen CCH 70 - 3		Zonen	(a)	I		II		III		IV		V		VI		VII		VIII		IX		X			
		Prüfungen	(b)	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H		
		Oberflächen	(c)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)	12.5	(f)
		PT	(d)		X		X		X		X		X		X				X					X	
		MT	(d)	X	X	X		X		X		X	X	X	X	X		X	X	X			X		
		UT	(d)																				X		
		RT	(d)																						
		Annahmekriterien auf :	Stück	PT	§ 4.3		2		3		3		3		3		3			3					3
MT	§ 6			2	2	2		2		2		2	3	2	3		2	2	4			3			
UT	§ 1.7 / 2.7																						3		
RT	§ 11.1																								
Schweiss.	UT		§ 1.9 / 2.7.1																						
	RT		§ 11.2																						

ZONENEINTEILUNG

Referenzmass für die Bestimmung der Zonen : 2800 mm

(*) für Durchstrahlung (mm)

(a) Siehe Skizze (b) G = Giesser H = Hersteller (c) Siehe Rückseite (d) Gemäss Spezif. CCH 70-3 (e) Nichtzutreffendes streichen (f) Siehe Zeichnung	Name und Visum	Erstellt durch	Geprüft durch	Genehmigt durch	*Konstrukteur
					«X X X X X»
	Datum				

QUALITY SHEET

Nr QS - 0030

CCH 70-3

Power plant VINH SON
 Drawings Nr 41 713 B
 Customer / Country «V»
 Designer «X»
 Founder «Y»
 Manufacturer «Y» = «Z»

Quantity and designation 2 PUMP/TURB. RUNNERS
 Unitary weight (finished casting) 19.000 kg
 Inquiry Nr 3542 dated 18.11.95
 Order Nr 120711 dated 15.02.96
 Inspection at F's works by «W» + «X» (b)
 Inspection at M's works by «W» + «X» (b)

CHARACTERISTICS OF MATERIAL

Designation : G - X5 Cr Ni 13.4

According to standard : analogic DIN 17445

Values or ranges required	Chemical	C %	Mn %	Si %	Cr %	Ni %	Mo %	S %	P %	S+P %	
		≤ 0.05	≤ 1.5	≤ 1.0	12.0/13.5	3.5/5.0	≤ 0.7	≤ 0.015	≤ 0.025	≤ 0.030	
	Mechanical properties	Rm MPa	Rp0.2 MPa	A5 %	Z %	CVN (e) J at t °C	H B	Inspection certificate			
		730/840	540/710	≥ 15		≥ 75.0 - 20°	240/300	according to EN 10240			

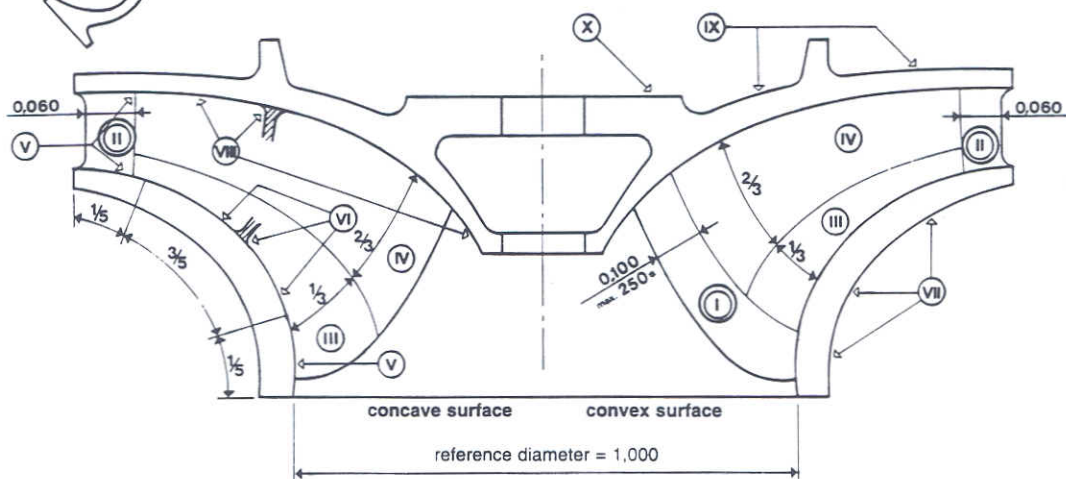
NON DESTRUCTIVE TESTINGS

The Designer's requirements are indicated in the table below by **X** (or by QL, QP, SL according to UT 30-3 § 1.4.2)

Technical Specifications CCH 70 - 3		Areas	(a)	I		II		III		IV		V		VI		VII		VIII		IX		X			
		Inspections	(b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M		
		Surface quality	(c)	N9	N7	N9	N7	N9	N7	N10	N8	N9	N7	N9	N7	N10	N7	N9	N8	N10	N8	N10	N7		
		PT	(d)		X		X		X		X		X		X		X		X		X		X		
		MT	(d)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
		UT	(d)													X					X		X		
		RT	(d)																						
		Acceptance criterias on :		Casting	PT	(c)	§ 4.3		2		2		2		3		2		3		2		2		2
MT	(c)				§ 6	2	2	2	2	2	2	3	2	L2 P3	L2 P3	L2 P3	L2 P3	L2 P3	2	L2 P3	L2 P3	L2 P3	2	L2 P3	2
UT	§ 1.7 / 2.7																3				3		2		
RT	§ 11.1															A3 B2 C2				A3 B2 C2		A2 B2 C2			
Repairs	UT			§ 1.9 / 2.7												3				3		2			
	RT			§ 11.2												A3 B2 C2				A3 B2 C2		A2 B2 C2			

SKETCH DEFINING THE AREAS

Reference dimension for the areas : 950 mm



(*) for radiography (mm)

(a) See sketch (b) F=Founder M=Manufacturer (c) See back (d) According to spec. CCH 70-3 (e) Delete where not applicable (f) See casting's drawing	Name and signed	Established by	Checked by	Approved by	"Designer"
					«X X X X X»
	Dated				

MECHANICAL TESTS at the FOUNDER'S WORKS, according to GE 70-3, § 2.2

(*) = Delete where not applicable

«Cast-on» test-coupons. (*)

~~«Separately cast» test-blocs. (*)~~

Number of test-coupons : (*)

2

-

per casting,

~~per lot of castings coming from the same heat,~~

i.e. :

1

to be tested and

1

for retest.

Position and dimensions of the test-coupons are given by the Designer, either on the drawing or on the sketch of the Q.S. If nothing has been specified, the choice will be left to the Founder.

Before removal, the test-coupons will be stamped and identified by the Founder in the presence of : «Y» and/or «X»

Stress relieving heat treatment : (*) - with test-coupons reattached on the castings.
~~- simulated stress relieving of test-coupons.~~

Test specimens :

Each test-coupon shall give

1

3

tension-test specimen(s) and

impact-test specimens.

Standard(s) :

Nr _____

Chapter	§	CHECK-LIST of other requirements from DESIGNER, according to the symbols ♦ in margin (see Introduction, § 5)	Annex Nr	Page
GE	1.4	Conditions of heat treatments are to be communicated to the Designer.	A	3
GE	1.5	Procedure for reception specified by the Customer (advance notice, aso.)	B	3
GE	2.1	Check-analysis on casting, if required.		
GE	2.2.1.3	Hardness test on casting, if required.	C	3
GE	3.1	Special surface qualities (possible code).		
GE	3.3	Pressure test, if required.		
GE	3.4	Runner balancing : requirements.	D	3
GE	4.1	Dimensional inspections and tolerances.	E	4
GE	5.1.2.1	Other definition of «major» repairs.		
GE	5.1.2.2	Designation of «highly stressed» areas. <i>Blade corner (0,05 x Réf.) : PT + MT Classe 1</i>	F	4
GE	5.1.3	Other acceptance criterias in excavations (welding preparation).		
GE	5.1.4	Other convention relative to quality of repair weldings.		
GE	5.2.3	Designation of excavations to be submitted for weld approval.		
GE	5.3.3	Mutual agreement regarding repartition of cost of repairs.		
GE	7.2	Conditions and duration of guarantee granted by the Designer.	G	4
PT	3	Other method and process, if required.		
MT	3.1.2	Process of magnetization required or particular procedure.		
MT	4.3	Type of agent for detection, if required. <i>liquid ink / fluorescent light.</i>		
MT	7.2	Admissible residual magnetization, if required. <i>max 600 A/m (8 Oe)</i>	-	-
UT	0.2	Transverse wave examination, if specified.		
UT	1.2	Method to be use : CAD or AVG. (*)	-	-
UT	1.3.2	Type of probe to be use.		
UT	1.3.4	Special type of couplant, if required.		
UT	1.4.2	Definition and location of a network, if required.		
UT	1.9	Possible supplementary inspections on «major» repairs.		
UT	2.2	Method to be use : CAD or AVG. (*)	-	-
UT	2.4.2	Other limits than proposed by figures 7 to 11.		
RT	2	Other specific procedure, if required.		
RT	10.1	Type of IQI, if required.		
RT	10.3	Duration for archiving of films.		
RT	11.2	<i>Only if UT in not clear and RT possible.</i>	-	-
				2 / 4

Anlage BEAVERDAM
 Zeichnungen Nr 81.625.750 B
 Kunde / Land «V»
 Konstrukteur «X»
 Giesser «Y»
 Hersteller «Z»

Anzahl und Bezeichnung 10 KAPLANSCHAUFELN
 Einzel-Fertiggewicht 4850 kg
 Anfrage - Nr 9644 vom 18-04-96
 Bestellung - Nr 723-466 vom 12-07-96
 Abnahme beim G durch «V» + «X» + «Z» (b)
 Abnahme beim H durch «V» + «X» (b)

MATERIALEIGENSCHAFTEN

 Bezeichnung : A743 Grade CA-6NM

 gemäss Norm : ASTM

Vorgeschriebene Grenzwerte	Chemische Zusammensetzung	C %	Mn %	Si %	Cr %	Ni %	Mo %	S %	P %	S+P %	
		≤ 0.06	≤ 1.0	≤ 1.0	11.5 / 14.0	3.5 / 4.5	0.4 / 1.0	≤ 0.020	≤ 0.025	≤ 0.035	
Mechanische Eigenschaften	Rm MPa	Rp0.2 MPa	A5 %	Z %	CVN (e) bei 0°C	H	Abnahmeprüfzeugnis				
	≥ 755	≥ 550	≥ 15	35	≥ 32	0°	gemäss <u>EN 10204 (3.1C)</u>				

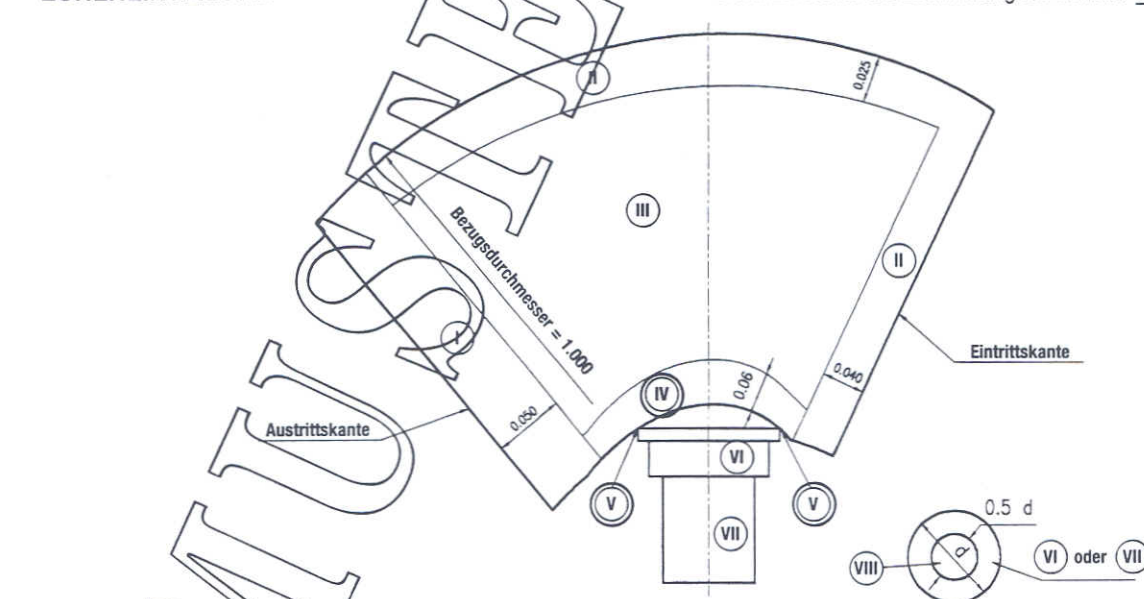
ZERSTÖRUNGSFREIE PRÜFUNGEN

* (21.5 min. indiv.)

 Die vorschritten des Konstrukteurs sind nachstehend mit **X** (oder mit **QL**, **QF**, **SL** gemäss UT 70-3 § 1.4.2)

Technische Spezifikationen CCH 70 - 3		Zonen	(a)	I		II		III		IV		V		VI		VII		VIII		IX		X		
		Prüfungen	(b)	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	
		Oberflächen	(c)	2S1	3.2	2S1	3.2	2S1	6.3	2S1	3.2	3S2	3.2	12.5	(f)	12.5	(f)	-	-					
		PT	(d)		X		X		X		X		X											
		MT	(d)	X		X		X		X	X	X	X	X		X								
		UT	(d)	X										X		X		X						
		RT	(d)	X																				
		Annahmekriterien auf : Schweis.		Stück	PT	§ 4.3	2	3	4	3	1													
MT	§ 6				2	3	3	2	2	2	1	3	3											
UT	§ 1.7 / 2.7				2								3	4	5									
RT	§ 11.1				3																			
UT	§ 1.9 / 2.7.1				X								X	X										
RT	§ 11.2				A3 B3 C3																			

ZONENEINTEILUNG

 Referenzmass für die Bestimmung der Zonen : 5820 mm


(*) für Durchstrahlung (mm)

(a) Siehe Skizze	Name und Visum	Erstellt durch	Geprüft durch	Genehmigt durch	"Konstrukteur"
(b) G = Giesser H = Hersteller					
(c) Siehe Rückseite					
(d) Gemäss Spezif. CCH 70-3					
(e) Nichtzutreffendes streichen					
(f) Siehe Zeichnung	Datum				

«X X X X X»

Centrale SAINT-GERMAIN
 Plans N° H - 27342 A
 Client / Pays «V»
 Constructeur «X»
 Fondateur (?)
 Réalisateur «X» = «Z»

Nombre et objet 19 CORPS D'INJECTEUR
 Masse unitaire (pièce finie) 670 kg
 Demande d'offre N° DO 7021 du 23-04-96
 Commande N° (interne «X») du -
 Réception chez F par (voir FQ - 96 - 0051) (b)
 Réception chez R par «W» (pour «V») (b)

CARACTÉRISTIQUES DU MATÉRIAU

Désignation : A216 Grade WCCSelon norme : ASTM

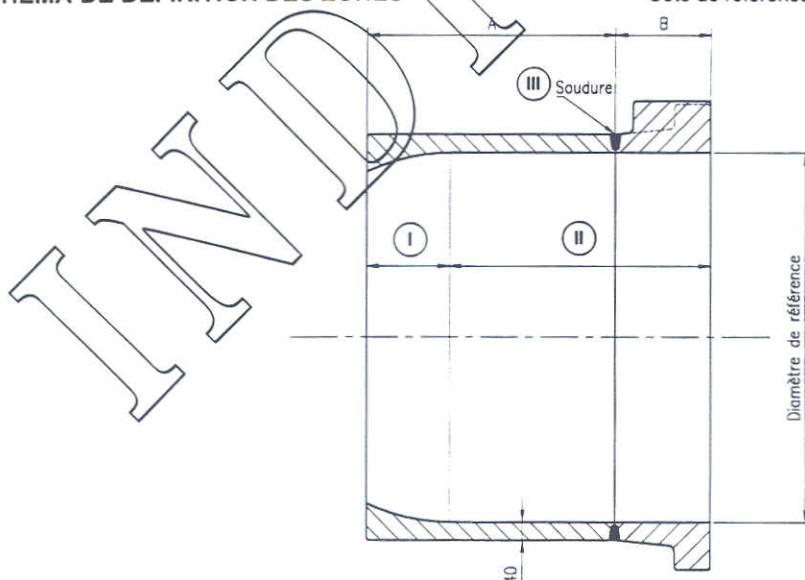
Valeurs ou fourchettes imp.	Composition chimique	C %	Mn %	Si %	Cr %	Ni %	Mo %	S %	P %	S+P %	
		≤ 0.25	≤ 1.20	≤ 0.60	≤ 0.50	≤ 0.50	≤ 0.20	≤ 0.040	≤ 0.040		
	Caractéristiques mécaniques	Rm MPa	Rp 0.2 MPa	A5 %	Z %	CVN (e) J	à t°C	H	Certificat de réception selon <u>EN 10204 3.1C</u>		
		485 / 655	≥ 275	≥ 22	35	≥ 24	0°				

EXAMENS NON-DESTRUCTIFS

Les prescriptions du Constructeur sont désignées ci-dessous par X (ou par QL, QP, SL selon UT 70-3 § 1.4.2)

Spécifications techniques CCH 70-3	Zones	(a)	I	II	III	IV	V	VI	VII	VIII	IX	X
	Examens	(b)	F R	F R	F R	F R	F R	F R	F R	F R	F R	F R
Critères d'acceptation sur :	Etat de surf.	(c)	(f)	(f)	3S2							
	PT	(d)	X	X	X							
	MT	(d)										
	UT	(d)			X							
	RT	(d)										
	RT	(d)										
Critères d'acceptation sur :	PT	§ 4.3	3	4	2							
	MT	§ 6										
	UT	§ 1.7 / 2.7			(c)							
	RT	§ 11.1										
	UT	§ 1.9 / 2.7.1			X							
	RT	§ 11.2										

SCHEMA DE DEFINITION DES ZONES

Cote de référence dimensionnant les zones : 660 mm

pour le détail
des 2 éléments A et B
voir Fiche Qualité
N° FQ - 96 - 0051

(a) Voir schéma (b) F= Fondateur R= Réalisateur (c) Voir au verso (d) Selon spécif. CCH 70-3 (e) Biffer la mention inutile (f) Voir plan de la pièce	Nom et signature	Etablis par	Contrôlé par	Approuvé par	"Constructeur"
	Date				"X X X X X"

Centrale SAINT-GERMAIN
 Plans N° H - 27342 A
 Client / Pays "V"
 Constructeur "X"
 Fondateur (?) = "Y"
 Réalisateur "X" = "Z"

Nombre et objet ELEMENTS pour 19 CORPS D'INJECTEUR
 Masse unitaire (pièce finie) A = 390 , B = 310 kg
 Demande d'offre N° DO 7025 du 28-04-96
 Commande N° _____ du _____
 Réception chez F par "W" (pour "V") (b)
 Réception chez R par (voir FQ - 96 - 0050) (b)

CARACTÉRISTIQUES DU MATÉRIAU

Désignation : A 216 Grade WCC

Selon norme :

ASTM

Valeurs ou fourchettes imp.	Composition chimique	C %	Mn %	Si %	Cr %	Ni %	Mo %	S %	P %	S+P %	Certificat de réception selon <u>EN 10204 - 3.1C</u>	
		≤ 0.25	≤ 1.20	≤ 0.60	≤ 0.50	≤ 0.50	≤ 0.20	≤ 0.040	≤ 0.040			
	Caractéristiques mécaniques	Rm MPa	Rp0.2 MPa	A5 %	Z %	CVN (e) J	à t °C	H				
		485 / 655	≥ 275	≥ 22	35	≥ 24	0°					

EXAMENS NON-DESTRUCTIFS

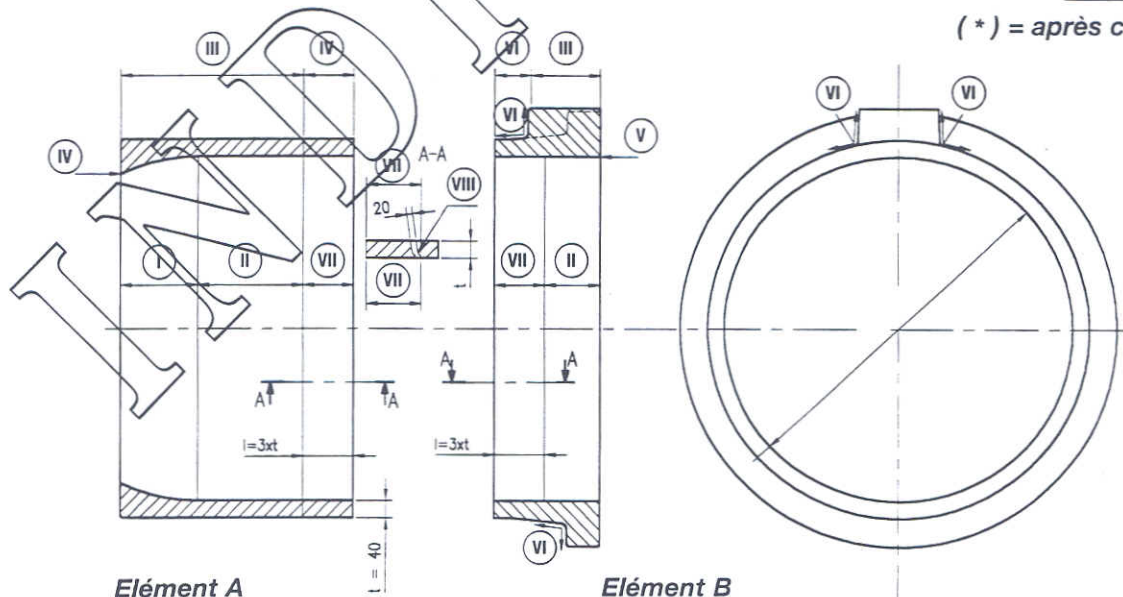
Les prescriptions du Constructeur sont désignées ci-dessous par X (ou par QL, QP, SL selon UT 70-3 § 1.4.2)

Spécifications techniques CCH 70-3	Zones	(a)	I	II	III	IV	V	VI	VII	VIII	IX	X
	Examens	(b)	F R	F R	F R	F R	F R	F R	F R	F R	F R	F R
	Etat de surf.	(c)	N10 (f)	N10 (f)	2S1 (f)	N10 (f)	N10 (f)	2S1 (f)	3S2 (f)	N9		
	PT	(d)										
	MT	(d)	X	X	X	X	X	X	X			
	UT	(d)		QL 100		X	X	X	X			
	RT	(d)										
Critères d'acceptation sur :	Pièce											
	PT	§ 4.3								1(*)		
	MT	§ 6	3	3	3	3	3	2	2			
	UT	§ 1.7 / 2.7		3		4	4		2	(c)		
	RT	§ 11.1		A2 B2 C2								
Répar.	UT	§ 1.9 / 2.7.1		X		X	X		X	X		
	RT	§ 11.2										

SCHÉMA DE DÉFINITION DES ZONES

Cote de référence dimensionnant les zones : 660 mm

(*) = après chanfrein



Elément A

Elément B

- (a) Voir schéma
 (b) F = Fondateur R = Réalisateur
 (c) Voir au verso
 (d) Selon spécif. CCH 70-3
 (e) Biffer la mention inutile
 (f) Voir plan de la pièce

Nom
et
signature

Date

Etablis par

Contrôlé par

Approuvé par

"Constructeur"

"X X X X X"

ESSAIS MÉCANIQUES chez le FONDEUR, selon GE 70-3, § 2.2

(★) = biffer les mentions non-retenues

~~Appendices d'essais «coulés attachés» (★)~~

Lingots-échantillons «coulés séparément» (★)

Nombre d'appendices d'essais. (★)

-

~~par pièce,~~

3

par lot de pièces issues d'une même coulée

soit :

2

pour essais et

1

pour contre-essais

Position et dimensions

des appendices d'essais sont fixés par le Constructeur, soit sur le plan soit sur le schéma de la F.Q. Si tel n'est pas le cas, elles sont laissées à l'initiative du Fondateur

Avant-prélèvement,

les appendices d'essais seront poinçonnés et identifiés par le Fondateur, en présence de : «W» (pour «V»)

Détensionnement : (★)

~~- détensionnement avec appendices d'essais attachés à la pièce.~~
- «détensionnement simulé» des appendices.

Éprouvettes :

Chaque appendice d'essais doit donner

2

éprouvette(s) de traction et

3

éprouvette de résilience.

Norme(s) :

N° ASTM A370

Chapitre	§	CHECK-LIST des autres prescriptions du CONSTRUCTEUR, selon les mentions ♦ en marge (voir Introduction, § 5)	Annexe N°	Page
GE	1.4	Modalités de traitements thermiques à communiquer au Constructeur.	A	3
GE	1.5	Modalités de réception imposées par le Client (préavis, etc.)		
GE	2.1	Contre-analyse sur pièce, si imposé.		
GE	2.2.1.3	Contrôle de la dureté sur pièce, si imposé		
GE	3.1	Etats de surface particuliers (codification éventuelle).		
GE	3.3	Contrôle d'étanchéité sous pression, si imposé. (voir FQ - 96 - 0050	-	-
GE	3.4	Equilibrage des roues : prescriptions imposées.		
GE	4.1	Contrôles et tolérances dimensionnels.		
GE	5.1.2.1	Autre définition des «affouillements majeurs».		
GE	5.1.2.2	Désignation des zones «fortement sollicités».		
GE	5.1.3	Autres limites d'acceptabilité sur les affouillements.		
GE	5.1.4	Autres conventions concernant les soudages de réparation		
GE	5.2.3	Désignation des affouillements soumis à «Autorisation de soudage».		
GE	5.3.3	Mode de répartition des frais de réparation.		
GE	7.2	Conditions et durée de garantie accordées par le Constructeur.	B	3
PT	3	Autre méthode et mode opératoire, si imposé.		
MT	3.1.2	Procédé(s) de magnétisation imposé(s) ou procédure particulière.		
MT	4.3	Nature du produit indicateur, si imposé. <i>liqueur magn. fluorescente</i>	-	-
MT	7.2	Taux d'aimantation résiduelle admissible, si imposé.		
UT	0.2	Recours à examen en ondes transversales. <i>oui, zone VIII (attente/chanfreins de soudage)</i>	-	-
UT	1.2	Méthode à utiliser. <i>CAD ou AVG. (★)</i>	-	-
UT	1.3.2	Type de traducteur à utiliser. <i>KRAUTKRAMER MWB 60 N4</i>	-	-
UT	1.3.4	Milieu de couplage particulier, si imposé.		
UT	1.4.2	Définition et repérage d'un réseau, si imposé.		
UT	1.9	Contrôles supplémentaires éventuels sur réparations «majeures». (voir § 2.7.1)	-	-
UT	2.2	Méthode à utiliser <i>CAD ou AVG. (★)</i>	-	-
UT	2.4.2	Autres limites que celles proposées par fig. 7 à 11.		
RT	2	Autre procédure particulière, si imposée.		
RT	10.1	Type d'IQI, si imposé.		
RT	10.3	Durée d'archivage des films.		
UT	1.7	Critère d'acceptation : classe 2	-	-
UT	2.7.1	Critères pour toutes les réparations de défauts mineurs ou majeurs.	-	-

GENERAL TECHNICAL RECEIVING SPECIFICATION

This specification contains the following chapters:

1 - GENERAL REQUIREMENTS

- 1.1 Preamble
- 1.2 Personnel and equipment of the **Founder** and (or) the **Manufacturer**.
- 1.3 Steel melting
- 1.4 Heat treatments
- 1.5 Reception

2 - MATERIAL INSPECTIONS

- 2.1 Chemical composition
- 2.2 Mechanical properties

3 - NON-DESTRUCTIVE INSPECTIONS

- 3.1 Visual inspection
- 3.2 Soundness checks:
 - by dye penetrant inspection
 - by magnetic particle inspection
 - by ultrasonic inspection
 - by radiographic inspection
- 3.3 Water tightness under pressure test.
- 3.4 Runner balancing

4 - DIMENSIONAL INSPECTIONS

- 4.1 At delivery stage by the **Founder**
- 4.2 At delivery stage by the **Manufacturer**

5 - ELIMINATION OF DEFECTS

- 5.1 General considerations
- 5.2 Defects revealed at the **Foundry**
- 5.3 Defects revealed at the **Manufacturer** or **Designer's** works
- 5.4 Defects revealed at the **Customer's** Powerplant.

6 - NON-CONFORMITIES

7 - GUARANTEE.

1 - GENERAL REQUIREMENTS

1.1 PREAMBLE

In case of disagreement between the **Customer**, **Designer**, **Manufacturer** and **Founder** on the choice of inspection means to be used, their application, or in the interpretation of the results obtained, the **Designer's** ruling shall have precedence because of his own commitments.

1.2 PERSONNEL AND EQUIPMENT OF THE FOUNDER AND (OR) MANUFACTURER.

The **Founder** and/or the **Manufacturer** will have a written Quality Assurance Program based on the requirements of **ISO 9002**. If the program hasn't been certified by an accredited organization, the **Designer** will verify that the program meets his own criteria.

The **Designer** will make sure, based on the evaluation procedure of his suppliers that they are able to manufacture the parts in question.

1.3 STEEL MELTING

Normally the steel used should be elaborated in an electrical furnace. Retreating by supplementary metallurgical methods : A.O.D., V.O.D., A.P.C (*) can be accomplished so as to obtain better welding capabilities, high impact strength values and improvement in the soundness of the parts.

- (*) AOD: Argon Oxygen Decarburization
- VOD: Vacuum Oxygen Decarburization
- APC : Ladle refining (Affinage Poche Chauffante)

1.4 HEAT TREATMENTS

The conditions for the performance of the heat treatments, position of the part in the furnace, number and position of the thermocouples will be defined by the **Founder** and/or the **Manufacturer**. They will be communicated to the **Designer** should he request it.

1.4.1 Quality heat treatment.

The choice of the appropriate quality heat treatment parameters determining the mechanical properties will be left to the **Founder**. They must conform to the existing standards and/or the specific requirements of the contract.

1.4.2 Stress relieving heat treatment

After welding a stress relieving treatment is to be carried out except in special cases (see paragraph 5). It's cycle will be in conformity with the welding process qualifications and procurement specifications. The **Founder** or the **Manufacturer** will have to obtain the agreement of the **Designer** on the conditions of this heat treatment.

1.4.3 Heat treatments documentation

All the thermal cycles applied will be recorded and the diagrams will be kept at the disposal of the **Designer** at the **Founder's** or at the **Manufacturer's** works.

A summary of the cycles performed will be described either on the mechanical properties certificate or on a heat treatment certificate (heating and cooling rate, holding temperature with maxi deviations, holding time).

1.5 RECEPTION.

The reception inspections to be carried out by the **Founder** and/or the **Manufacturer** are defined by the **Quality Sheet**; they may comprise checking of the chemical composition and the mechanical properties, (at the **Founder** only) as well as the non destructive inspections. These tests are carried out by the **Founder** and/or the **Manufacturer** in the presence of the **Designer** and/or the **Customer** if specified in the order. In this case the **Founder** and/or the **Manufacturer** will inform the **Designer** in writing as specified in the order.

The **Designer** shall inform the **Founder** and/or the **Manufacturer** of the date of his arrival and/or of the arrival of his **Customer** at the **Founder's** or the **Manufacturer's** works.

At time of final reception, the contractual documents of manufacturing and inspections will be put at the disposal of the **Designer** or his representative.

2 - MATERIAL INSPECTIONS

2.1 CHECKING OF THE CHEMICAL COMPOSITION

The chemical composition of the heat will be checked by the **Founder** and indicated on the certificates. A check-analysis on the casting may exceptionally be taken into consideration if agreed by the parties. The steel grade has to be clearly defined in the inquiry to the **Founder**. The **Founder** will state in his offer the chemical composition of the material to be supplied and the **Designer** will mention it in his order and in the **Quality Sheet**.

Generally the following values are recommended for sulphur and phosphorus contents:

For unalloyed or slightly alloyed steels:
 $S \leq 0.030\%$ $P \leq 0.030\%$

For martensitic alloyed steels 13-4 without specified minimum molybdenum content, the **Designer** may impose more restrictive values for sulphur and phosphorus than those indicated in the standard:

$S \leq 0.015\%$ $P \leq 0.025\%$ but $S + P \leq 0.030\%$
 $Si \leq 0.50\%$

2.2 VERIFICATION OF MECHANICAL PROPERTIES

2.2.1 Imposed values

The values of the mechanical properties will be indicated in the **Quality Sheet**.

Generally the tests will check for the following mechanical properties :

1 - Tensile test :

-Tensile Strength :	Rm in MPa
-Yield stress :	Rp 0.2 in MPa
-Elongation (5d) :	A5 in %
-Reduction in area :	Z in %

2 - Impact test at the temperature required by the **Quality Sheet** :

- Impact strength : CVN or CUN in J (Joules)
(Charpy V Notch or Charpy U Notch)

3 - Hardness test if required

- Number and position of check points.

The number of test specimens required is always meant per casting (not per heat). In case a serie of pieces is cast from the same heat, the necessary number of tests per lot will be fixed by the **Designer** and if required the verification of hardness per casting to control the homogeneity of the lot in question.

2.2.2 Testing conditions

The tests will be carried out on test specimens cut from cast-on test coupons remaining attached to the casting throughout the quality heat treatment. Whenever technical reasons require that the test-coupons are removed before the quality heat treatment, they will be detached and subsequently reattached to the casting in the presence of or in agreement with the **Designer** and/or the **Customer** before quality heat treatment. The test-coupons will be cut-off after quality heat treatment eventually before rough machining, in the presence or after the agreement of the **Designer** and/or of the **Customer**.

The **Designer** may request:

- either the presence of test-coupons on the part during the stress relieving heat treatment; these coupons will have been removed and stamped by the **Designer** or the **Customer** before rough machining and then re-attached to the casting by the **Founder**.
- or a simulated stress relieving.

If, for technical reasons, the test-coupons cannot be cast on, separately cast test blocks may be used if previously approved by the **Designer** and/or **Customer**.

2.2.3 Number and position of the test coupons

The number, position and dimensions of the test-coupons will be determined by common agreement between the **Designer** and the **Founder** and will be indicated on the **Quality Sheet**.

The **Founder** will provide supplementary test coupons necessary for his internal tests.

2.2.4 Testing installations and personnel

All necessary tests will be carried out by the personnel of the **Founder's** inspection department, using the testing equipment available at the **Foundry**.

The test equipment shall be calibrated periodically. The calibration reports shall be placed at the **Designer's** and the **Customer's** disposal. No special calibration will be carried out.

3 - NON DESTRUCTIVE INSPECTIONS

The nature of the non destructive inspections as well as the areas to which the various examinations apply, must be clearly defined on the **Quality Sheet** attached to the inquiry and the order addressed to the **Founder** and/or the **Manufacturer**.

The non destructive inspections will be performed exclusively by qualified and certified personnel in conformity with standard EN 473 or a recognized equivalent system (example : SNT TC 1A or ISO 9712).

The qualification procedures, the qualification levels of the operators and their maintenance, shall be described in the Quality Assurance program of the **Founder** and/or **Manufacturer**. If the **Founder** and/or the **Manufacturer** does not have such procedures which are accepted by the **Designer**, he will provide other inspectors certified and recognized by the **Designer**.

3.1 VISUAL INSPECTION

Non destructive testing will be preceded by a visual inspection. The visual inspection will cover the entire casting under the following aspects:

- 1 - Identification,
- 2 - Surface quality,
- 3 - Visible defects,
- 4 - Conformity to the documents of the order.

This visual inspection may be carried out with reference to a specification as, for instance, technical recommendation BNIF 359.01 of the "Bureau de Normalisation des Industries de la Fonderie" (Foundry Industry's Standardization Office) or ASTM A802 for the surface quality and MSS-SP 55 specification for visible defects or any other specification indicated on the **Quality Sheet**.

For the surface roughness of machined or fine ground areas, it is recommended to use the designations N1 to N11 of the ISO 2632 document which is referred to in numerous standards.

Dimensional aspects should be verified in accordance with the criteria described in paragraph 4.

3.2 SOUNDNESS CHECKS

3.2.1 Operating conditions and specifications

The operating conditions and acceptance classes are described in the following procedures:

PT 70-3	Technical Specification for dye penetrant inspection,
MT 70-3	Technical Specification for magnetic particle inspection,
UT 70-3	Technical Specification for ultrasonic inspection,
RT 70-3	Technical Specification for radiographic inspection.

3.2.2 Choice of inspection methods

The choice of inspection methods and of the acceptance classes should be a function of the working conditions under which the casting will operate, considering its hydraulic design and its service conditions (erosion, cavitation, shock loading, fatigue, working stresses of the different areas, etc.). It is the **Designer** who makes these choices.

3.3 PRESSURE TEST

The parts subjected to pressure are submitted to a test after finishing in the **Manufacturer's** or **Designer's** works or at site. The **Designer** must specify on his drawing the exact information about the testing conditions (type of fluid, pressure, test duration), in such a way that the **Founder** may manufacture the casting in full knowledge of the responsibilities in question. ◆

3.4 RUNNER BALANCING

The static balancing is the standard procedure.

To perform the runner balancing, the **Designer** must indicate the procedure, the standard to be used and the maximum acceptable imbalance in Kgm, as well as the sensitivity of the method to be used.

The **Designer** shall indicate by which means and where the non acceptable imbalance will be eliminated or compensated. ◆

4 - DIMENSIONAL INSPECTIONS

4.1 AT DELIVERY STAGE BY THE FOUNDER

The dimensional inspection conditions and the tolerances to be achieved by the **Founder** will be determined by the **Designer** in his inquiry. Due to the complexity of dimensional tolerances conditioned by the hydraulic shape of the castings it is extremely difficult to establish general rules. Thus, in his offer, the **Founder** will accept or discuss the required tolerances. ◆

It should be pointed out that tolerances have a direct influence on the price of the casting.

4.2 AT THE DELIVERY STAGE BY THE MANUFACTURER

As far as the surface continuity profiles are concerned (ondulations) and the hydraulic dimensions which are not covered by the CEI recommendations (CEI = Commission Electrotechnique Internationale, last edition for hydraulic turbines and storage pumps), the **Designer** will be the only judge concerning the acceptability of dimensional deviations and will evaluate their consequences on the working performance he guarantees.

5 - ELIMINATION OF DEFECTS

5.1 GENERAL CONSIDERATIONS

5.1.1 Classification of defects based on their origin.

Rules for assumption of costs of repairs.

- 1 - Defects for which the **Founder** is responsible are defects of metallurgical origin or defects resulting from the **Founders** manufacturing Technique.
- 2 - Defects for which the **Manufacturer** is responsible are those resulting from the manufacturing of the product in the works.
- 3 - Defects for which the **Designer** is responsible are those resulting from the design and the dimensioning of the casting.
- 4 - Possible defects for which the **Customer** is responsible would be those caused by exploitation conditions exceeding the guarantee given by the **Designer**, as well as for defects resulting from wear due to abrasion of material due to the quality of the water used.

As a rule, both the **Founder** and the **Manufacturer** or the **Designer** are liable for the repair of defects for which they are responsible, i.e. for defects exceeding the acceptance criteria required by the **Quality Sheet** and discovered by one of the inspection methods prescribed in the same **Quality Sheet** or by simple visual inspection.

5.1.2 Classification of defects based on their dimensions and on the degree of stress in the area considered.

1 - Dimensions

Excavations are considered " MAJOR" when either of the following criteria (maximum depth /surface) are exceeded. In the absence of specific instructions issued by the **Designer** in his **Quality Sheet**, the following criteria are applicable:

Reference dimension (according to Quality Sheet) (in mm)	≤1000	> 1000 ≤ 2000	> 2000 ≤ 4000	> 4000	units
Depth :					
in % of local thickness	40	35	30	25	%
but limited to:	10	15	20	25	mm
Surface	40	65	100	160	cm ²

2 - Degree of stress level

The highly stressed areas will be indicated on the **Quality Sheet** by two concentric circles. ◆

5.1.3 Welding preparation (excavations)

Before repair by welding, the defects have to be completely removed until the disappearance of any indication above class 1 of PT 70-3 or of MT 70-3. This principle is applicable for excavations corresponding to 1/3 of the thickness with a maximum of 30 mm.

Beyond this depth, class 3 in PT or class 2 in MT is applicable.

For certain highly stressed areas the **Designer** may specify more severe criteria. ◆

5.1.4 Criteria of acceptance for repair welding

Unless otherwise stipulated in the order, the repaired areas will be inspected by the same methods and acceptance criteria as initially required for the area in question. ◆

5.1.5 Waiving of repair by welding

The **Designer** may accept at any time, on his own responsibility, that certain excavations are not built up by welding, provided that no defects exceeding the acceptance criteria are left on the casting, and if the presence of the excavation does not interfere with an unobjectionable functioning of the casting.

5.2 DEFECTS REVEALED AT THE FOUNDRY

5.2.1 Repair by welding

Defects discovered during manufacturing in the **Foundry** will be excavated and repaired by welding.

5.2.2 Report of areas to be repaired

The dimensions and positions of major excavations exceeding the acceptance limit (as set by 5.1.2.1) as well as those in highly stressed areas (5.1.2.2) will be reported and if required completed by photos.

This report will be submitted to the **Designer**.

5.2.3 Welding approval

The **Designer** will specify on the **Quality Sheet** the excavations which must be submitted to him for approval before repair of defects (for example major excavations or excavations located in highly stressed areas). ◆

- 1 - The welding procedure will be qualified.

Any existing certified qualifications corresponding to the criteria defined will not be renewed.

- 2 - Welders and operators will be qualified.

- 3 - The welding procedure and if needed the welding procedure homologation, as well as the welders qualifications, must be submitted to the **Designer** for approval prior to the starting of the repair work.

- 4 - The **Designer** will grant his welding approval on the basis of the list of areas to be repaired (5.2.2) as well as on the basis of the PT and MT inspection reports issued as result of the excavations (5.1.3).

5.2.4 Stress relieving

A furnace stress relieving treatment will be carried out after welding. This heat treatment may only be omitted with the agreement of the **Designer** (see 1.4.2).

5.3 DEFECTS REVEALED AT THE MANUFACTURER'S OR THE DESIGNER'S WORKS

If the **Designer** decides for weld repairs on defects appearing during machining they will be performed under the following conditions.

5.3.1 Welding repairs with imposed stress relieving

Major repairs in the sense of § 5.1.2.1 and/or minor repairs in stressed areas (5.1.2.2) which require subsequent stress relief.

These repairs are executed by the **Founder** and are recorded. They may be undertaken by the **Manufacturer** or the **Designer** (after the approval of the **Founder**) in accordance with the agreed and qualified welding procedure.

5.3.2 Welding repairs without stress relieving

Located in less stressed areas repairs may be made by the **Manufacturer** or the **Designer** (after advising the **Founder**), subject to the agreed and qualified procedure.

5.3.3 Repartition of costs of repair

It is recommended to lay down in writing, after mutual agreement and **before placing an order**, the repartition of costs of repairs of possible arising repairs. If such measures have not been taken, the repartition of costs should be fixed by a mutual agreement between the **Founder**, the **Manufacturer** and the **Designer** prior to the commencement of work. The repartition of repair costs may, for instance, be fixed on the basis of one of the criteria mentioned hereafter:

- Surface inspection (dye penetrant, magnetic particle),
- Volume and number of excavations,
- Based on the selling price of the casting.

5.4 DEFECTS REVEALED AT THE CUSTOMER'S POWERPLANT

5.4.1 Warranty work

During the period of guarantee, repairs will be carried out by the **Founder**, the **Manufacturer** or the **Designer**. The costs will be spread in accordance with 5.1.1 and 5.3.3.

5.4.2 Repair beyond the warranty period

After the warranty period, repairs may be executed under the **Customer's** responsibility with the prior advise given to the **Designer**. The **Designer** may advise the **Founder** for information purposes. The **Customer** will assume the cost of repairs.

6 - NON CONFORMITIES

The **Founder** or the **Manufacturer** will rapidly inform the **Designer** of any deviation found. The **Designer** decides to either:

- accept in present states,
- repair and use the part,
- scrap the part.

Subject to the conditions of his contract, the **Designer** will advise the **Customer** of the decisions taken or will by agreement with the latter, find an acceptable solution.

Acceptance of a non conformity by the **Customer** in no way discharges the **Founder**, the **Manufacturer** or the **Designer** from their respective responsibilities.

7 - GUARANTEE

- 7.1 Within the limits specified in § 5, the present guarantee covers all deviations susceptible to interfere with the proper operation of the component considered, or to impair the security of the machine.

This guarantee engages the **Designer**, **Manufacturer** and **Founder** to carry out all necessary repairs as soon as possible, by appropriate professional techniques defined by the CCH 70-3 and procedures, and to ensure that the state of the repaired casting meets the original specifications or, if such specifications have not been established to meet the **professional standard**.

- 7.2 As the guarantee conditions of the **Founder** and **Manufacturer** are closely connected with the **Designer's** guarantee to his **Customer** for the hydraulic machine to be delivered, the **Designer** is obliged to inform the **Founder** and the **Manufacturer** before passing an order about his own engagements for the supply in question. The **Designer** will not be allowed to impose more severe conditions to the **Founder** and the **Manufacturer** than the ones he has accepted himself.
- 7.3 Contracts to which the present Specification for Inspection is applied are of mutual interest to the **Founder**, **Designer** and the **Manufacturer** and it will be essential to work in a sense of close cooperation to assure the required guarantee given.
- 7.4 The period of guarantee for the **Founder** and **Manufacturer** will be the same as that of the **Designer**. Usually, contracts for hydraulic machines require a guarantee covering a certain period of exploitation, after provisional reception of the installation, i.e. expressed in thousands of hours or in months, with a reasonable temporal limitation from a date, fixed in the contract between the **Designer** and the **Customer**.
Considering the diversity of cases and types of exploitation, the duration of the guarantee must be subject to commercial negotiations between the **Customer** and the **Designer** for each order.
- 7.5 Any request for application of the guarantee should be transmitted by the speediest means of communication as soon as a deviation has been discovered and subsequently confirmed in writing. On this occasion, any useful information should be transmitted to the party concerned.

- Nature of the defect
- Means by which it was detected
- Location
- Geometric dimensions of the defect (if possible with dimensioned sketch and photographs).

The party concerned by a request for application of the guarantee will as soon as possible propose an adequate repair procedure, execute the repairs and, in case of need, furnish the necessary pieces. It goes without saying that the party ensuring the guarantee reserves the right to view that the deviation occurred.

No repair will be effected without the agreement of the party considered responsible and only repairs which meet the instructions of this party will be carried out.
Any infringement of this regulation will lead to an annulment of any responsibility for the other party.

- 7.6 The validity of the guarantee is always subject to the operating and maintenance instructions specified by the **Designer**, and agreed by the **Customer**.

TECHNICAL SPECIFICATION FOR LIQUID PENETRANT INSPECTION

1 - OBJECTIVE AND FIELD OF APPLICATION

Liquid penetrant inspection is intended for the detection of defects open to the surface.

This method is generally limited to the inspection of finished castings. It may however be applied at earlier stages, especially for the inspection of excavations.

2 - SURFACE PREPARATION

It is essential that the surfaces to be inspected are clean and dry. That means that rust, scale, welding flux, spatter, grease, oil, water, dust, paint .. etc. are removed from the surface and the defects to be inspected.

Table 1

The surfaces shall be prepared according to acceptance criteria.

classes	Ra μm	Reference Plates			
		BNIF 359-01	Roughness test Nr 2 (LCA - CEA) Grinding	Roughness test Nr 3 (LCA - CEA) Grit blasting	ASTM A802
1	≤ 6,3	1S2, 2S2	≤ N9	prohibited	not applicable
2 to 3	≤ 12,5	1S1, 2S1 3S2, 4S2, 5S2	≤ N10	prohibited	not applicable
4 to 5	≤ 12,5	4S1, 5S1, 6S1	≤ N10	prohibited (*)	not applicable

(*) Sanding or grit blasting may be acceptable, subject to the Designer's approval.

In case of superficial mechanical treatment (e. g. scratching, hammering, shot blasting) which may dull the casting surface and thus hinder the penetration of the dye, the dye penetrant inspection should be preceded by a grinding of the surfaces to be inspected.

If magnetic particle inspection with liquid ink is intended, it is recommended to perform liquid penetrant inspection first.

3 - METHOD AND PROCESS

The general method uses a coloured water-washable liquid penetrant, visible in normal light, with which the surface to be inspected is wetted. The excess of penetrant will be washed off and the part dried. The examination is made after application of a coat of developer, suspended in a liquid. The products used shall be of high sensitivity.

The products generally available on the market and the operation methods described hereafter can be used within a temperature range of about 10 to 40° C of the surface to be inspected. Beyond these limits, the efficiency of the products and of the process must be proved at the temperature at which the inspection is intended to be carried out.

Any other method may be applied after previous agreement.

3.1 CLEANING

Rust, scale, welding flux, spatter, paint etc. shall be removed by means of a wire brush or by grinding. Then any traces of dust or grease have to be eliminated from the surface by means of a solvent or by means of steamed water under pressure. The products used must meet the requirements of National legislation with regard to the environment.

3.2 DRYING

It is essential that the surface to be examined is completely dried prior to application of the penetrant.

3.3 APPLICATION OF THE PENETRANT

The penetrant may be applied by dipping, brushing or by spraying (Aerosol or compressed air-type apparatus). Minimum penetration (soaking) time is 10 minutes, but longer penetration times may be necessary on polished surfaces, narrow discontinuities or at temperatures below 15 °C.

Generally, soaking times will be 10 to 20 minutes. It must be assured that the surface is kept wet during this period.

3.4 EXCESS PENETRANT REMOVAL

After the required penetration time, excess penetrant is removed by means of a wet cloth (sponge), by water rinsing or water spraying, at a water temperature below 40 °C and at a water pressure of less than 3.5 bar. The water jet shall be at least 30 cm from the surface. Then the part will be immediately dried with a dry, clean and lint free rag. The drying may be accelerated by using dry non oily compressed air at a pressure of less than 2 bar.

3.5 DEVELOPMENT

The developer must be applied **immediately** after the part to be examined is dry.

As developer, a suspension of powder in a solvent is used. It is recommended to apply the developer by a pistol immediately after preparation (mixing, shaking) to enforce uniform suspension. Other application methods (eg. aerosol spray) may be used as well, if they assure a thin and even film of developer, without flushing the penetrant within the discontinuities. Thick coats of developer are unacceptable. Drying is produced by natural evaporation.

3.6 EXAMINATION

Due to the rapid diffusion of the dye in the developer, it is recommended to observe the evolution of indications since application of the developer. After a developing time of 10 to 20 minutes, the indications will be compared with the acceptance criteria. Lighting should be higher than 500 Lux.

4 - INTERPRETATION OF RESULTS

4.1 DEFINITIONS

«Indications» are any detectable bleedouts after application of the developer

«Relevant» indications are those resulting from discontinuities.

«Rounded» indications are those which are more or less elliptic and their length is less than three times the average width.

«Linear» indications are those, in which the maximum length represents more than three times the average width extension.

«Aligned» indications are groups of three or more indications, aligned side by side, with a distance from edge to edge of less than 2 mm.

The «indications density» is the quotient (in 0/00)
$$\frac{\text{Total surface of indications taken into account}}{\text{Reference surface (1 dm}^2 \text{)}}$$

4.2 EVALUATION OF INDICATIONS

The threshold for taking the indications into account is defined for each class.

Surface imperfections, such as tool marks or other superficial surface conditions, are likely to produce indications. Any equivocal indication must be regarded as a defect and shall be re-examined, to verify whether or not real defects are present. Surface conditioning should precede the re-examination.

Broad areas of pigmentation are unacceptable without agreement of the Designer.

4.3 ACCEPTANCE CRITERIA

The inspected area will be evaluated and classified by comparison with the enclosed criteria which define five classes, numbered from 1 to 5 in decreasing order.

The reference surface of 1 dm², taken into consideration for this comparison, may be a square or a rectangle anyway, its length may not exceed 250 mm) depending on the morphology and the dimension of the inspected area or according to the most disadvantageous repartition of indications within the area concerned.

Cases of special indications or linear indications, which obviously are impossible to class, should be subject to an additional investigation for each particular case.

5 - INSPECTION REPORT

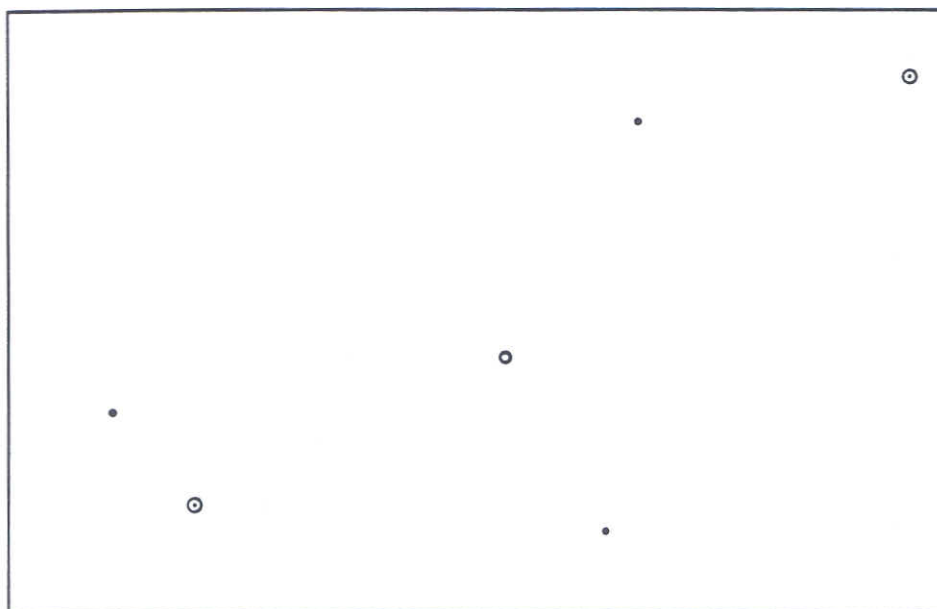
The inspection report shall include :

- Identification of the Founder, the Manufacturer or the Designer
- Identification of the casting (Heat Nr., traceability)
- Steel grade of the casting
- Designation of examination documents used: reference to the present specification, Quality sheet.
- Stage of manufacture at inspection
- Mode of surface preparation
- Designation of the products used
- Conditions of the inspection
- Inspected areas
- Results of inspection
- Name, signature and certification of inspector
- Identification of the firm in charge of inspection, if sub-contracted
- Date of inspection and signature of the responsible person for inspection

CLASS 1

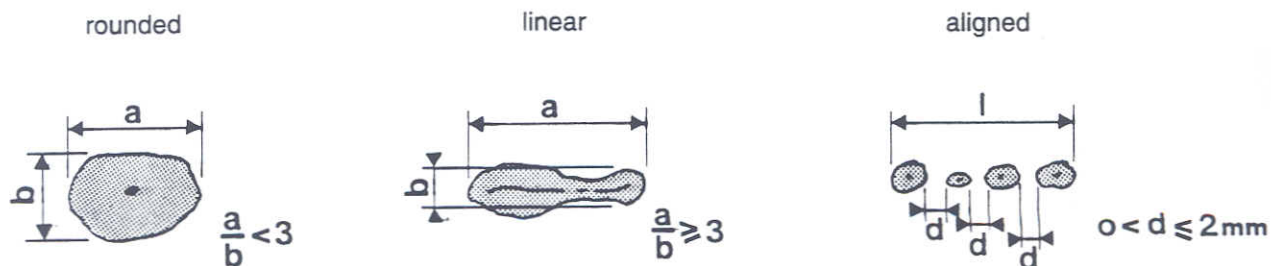
Acceptance criteria : (density 0,63 o/oo)

- 1) Threshold of accountability : $a = 0,5$ mm.
- 2) No rounded indication with a dimension of $a > 2$ mm.
- 3) No «linear» indication.
- 4) No «aligned» indication.
- 5) Total surface of the indications in the range of 6 to 7 mm².



Note : As a reference, the above example contains 6 indications, all taken into consideration. ($a > 0,5$ mm).
The total surface thus taken into account is of 6,3 mm².

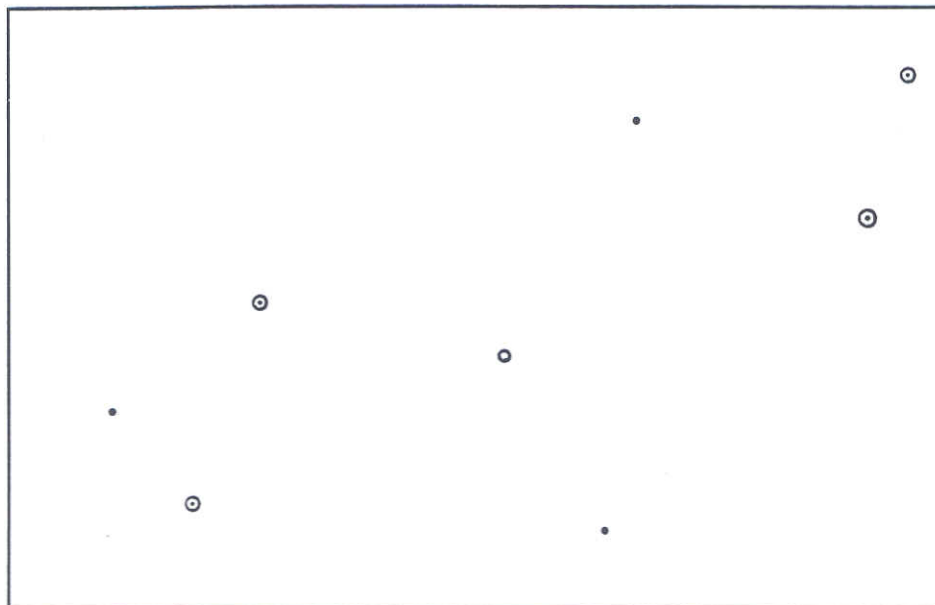
Definition of indications : (See PT 70-3 paragraph 4.1)



CLASS 2

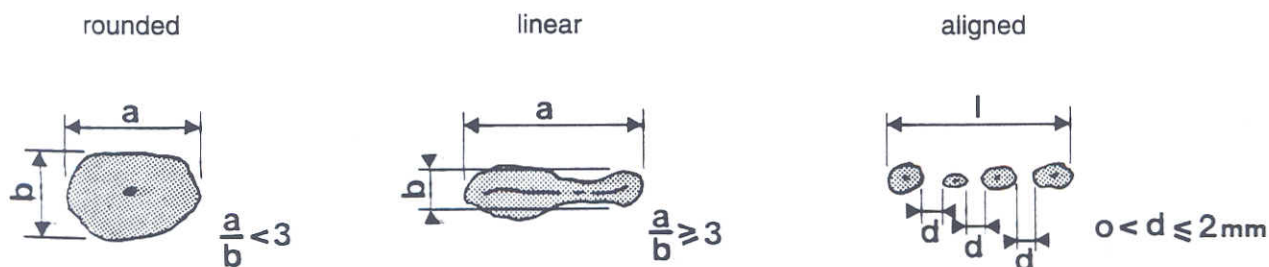
Acceptance criteria : (density 1,6 o/oo)

- 1) Threshold of accountability : $a = 1$ mm.
- 2) No rounded indication with a dimension of $a > 3$ mm.
- 3) No «linear» indication.
- 4) No «aligned» indication.
- 5) Total surface of the indications in the range of 16 mm^2 .



Note : As a reference, the above example contains 8 indications,
3 of which aren't taken into account. ($a < 1$ mm)
The total surface thus taken into account is of 16 mm^2 .

Definition of indications : (See PT 70-3 paragraph 4.1)





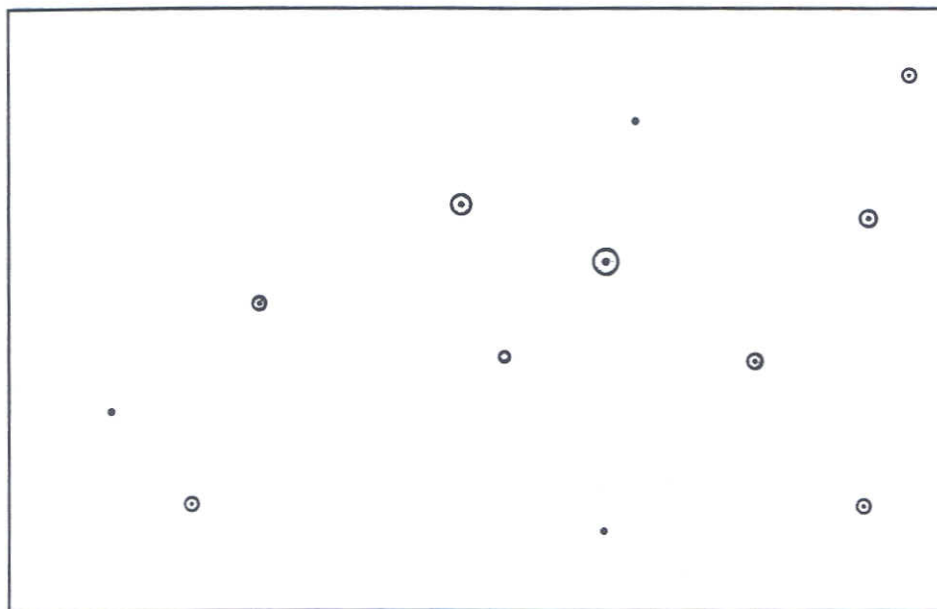
Lx



CLASS 3

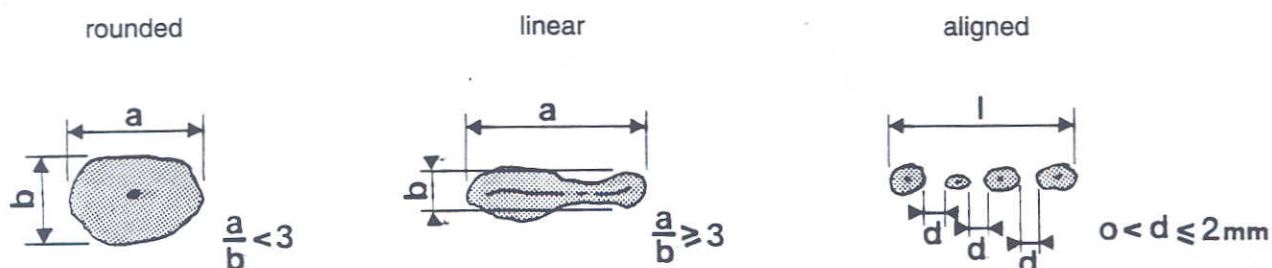
Acceptance criteria : (density 4,0 o/oo)

- 1) Threshold of accountability : $a = 1,5 \text{ mm}$.
- 2) No rounded indication with a dimension of $a > 4 \text{ mm}$.
- 3) No «linear» indication.
- 4) No «aligned» indication.
- 5) Total surface of the indications in the range of 40 mm^2 .



Note : As a reference, the above example contains 12 indications,
4 of which aren't taken into account. ($a < 1,5 \text{ mm}$)
The total surface thus taken into account is of 40 mm^2 .

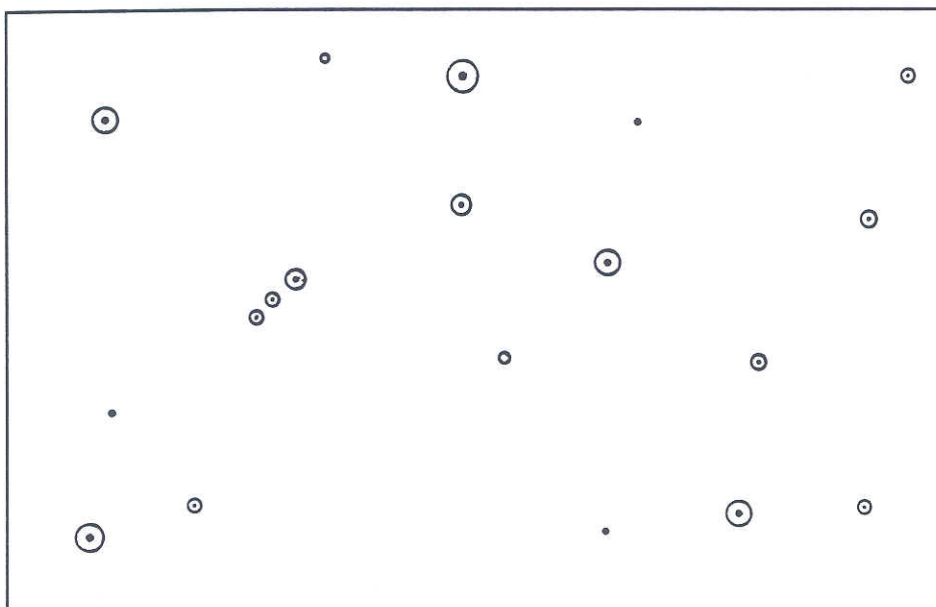
Definition of indications : (See PT 70-3 paragraph 4.1)



CLASS 4

Acceptance criteria : (density 10 o/oo)

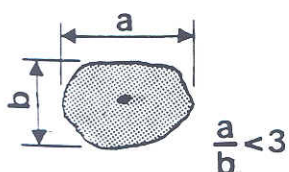
- 1) Threshold of accountability : $a = 1,5 \text{ à } 2 \text{ mm}$.
- 2) No rounded indication with a dimension of $a > 6 \text{ mm}$.
- 3) No «linear» indication.
- 4) No «aligned» indication of $l > 10 \text{ mm}$.
- 5) Total surface of the indications in the range of 100 mm^2 .



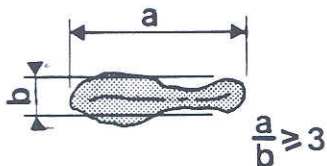
Note : As a reference, the above example contains 19 indications,
6 of which aren't taken into account. ($a < 1,5 \text{ to } 2 \text{ mm}$)
The total surface thus taken into account is of 100 mm².

Definition of indications : (See PT 70-3 paragraph 4.1)

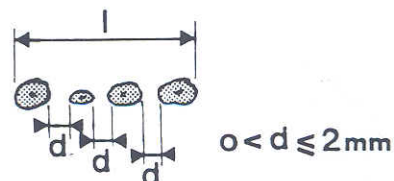
rounded



linear



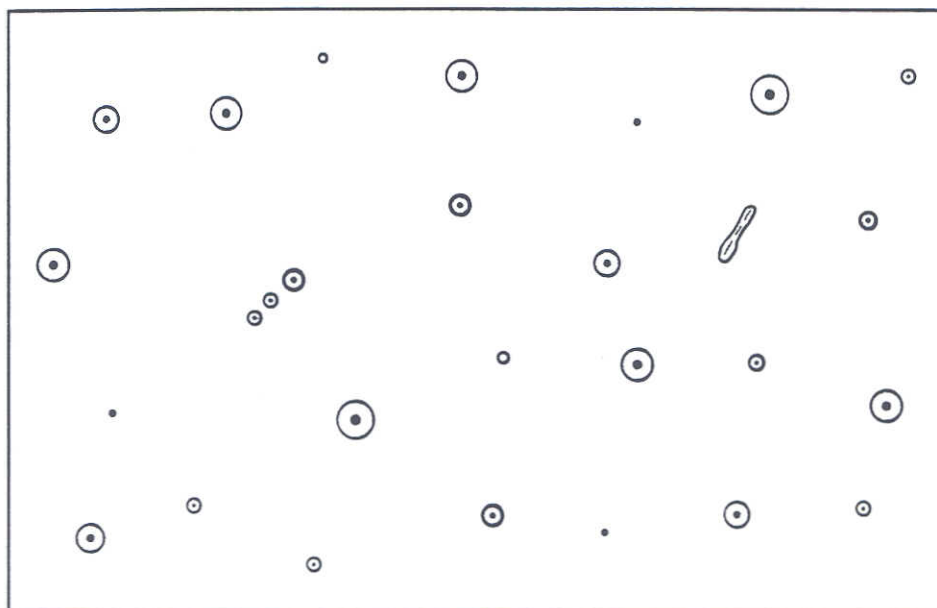
aligned



CLASSE 5

Acceptance criteria : (density 25 o/oo)

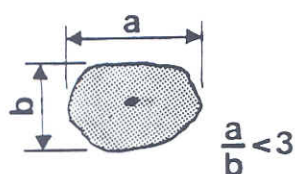
- 1) Threshold of accountability : $a = 2$ mm.
- 2) No rounded indication with a dimension of $a > 8$ mm.
- 3) No «linear» indication of $a > 7$ mm.
- 4) No «aligned» indication of $l > 16$ mm.
- 5) Total surface of the indications in the range of 250 mm^2 .



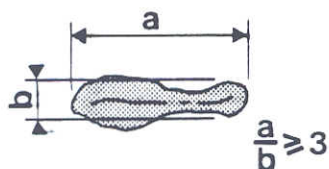
Note : As a reference, the above example contains 28 indications,
7 of which aren't taken into account. ($a < 2$ mm)
The total surface thus taken into account is of 250 mm².

Definition of indications : (See PT 70-3 paragraph 4.1)

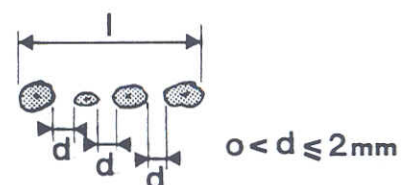
rounded



linear



aligned



TECHNICAL SPECIFICATION FOR MAGNETIC PARTICLE INSPECTION

1 - OBJECTIVE AND FIELD OF APPLICATION

The magnetic particle inspection is intended for the detection of superficial surface and sub-surface discontinuities on ferromagnetic material.

This examination is not applicable to austenitic steels and must be the subject of an agreement between the contractual parties in so far as the inspection procedures are concerned, when it is used on (Duplex) austenoferritic steels.

The magnetic particle inspection is generally carried out on as cast, rough machined or finished surfaces, while considering that there exists the possibility of deterioration of the parts when certain magnetization processes are used (superficial burning).

2 - SURFACE PREPARATION

The surfaces to be inspected must be clean, free of oil, grease, non adhering scales etc...) or any anomaly which could interfere with a clear interpretation of the examination.

Surface preparation intensity depends on the need to reveal finer discontinuities. The table below indicates the surface conditions and qualities requirede and defined in § 6.

Table 1

The surfaces are to be prepared in relation to the acceptance criteria.

classes	Ra µm	Standard surface specimen			
		BNIF 359-01	Roughness test Nr 2 (LCA - CEA) Grinding	Roughness test Nr 3 (LCA - CEA) (*) Shot blasting	ASTM A802
1	≤ 6,3	1S2, 2S2	≤ N9	sanding possible if Ra in conformitiy	not applicable
2 to 4	≤ 12,5	1S1, 2S1, 3S2, 4S2, 5S2	≤ N10	≤ N10	A1,B1,C1 A2,B2 H1, J1
5	≤ 25	4S1, 5S1, 6S1 1S3	≤ N11	≤ N11	≤ C2, D1, F1

(*) : Extensive shot blasting can prevent the visibility of defects and could even hide them; for this reason we recomend to limit shot blasting to a minimum.

3 - MAGNETIZATION METHODS

3.1 GENERAL

3.1.1 - The magnetic field must be of sufficient intensity to operate above the maximum magnetic permeability of the material.
This requirement is generally met with a tangential field of 2000 A/m (25 Oe) for unalloyed steels, (Average value of rectified current 1 alternation, effective value of alternating current); for alloyed steels, higher field values may be necessary. The value thus chosen must be considered as a minimum on the totality of the area inspected. A magnetic field of excessive value can cause the appearances of aberrant indications because of saturation.

3.1.2 - Magnetization is obtained through various processes indicated in § 3.2 and 3.3.

These processes are not equivalent to each other with regard to :

- the uniformity of the magnetization obtained
- the depth of detection
- the intensity of the tangential magnetic field obtained
- the implementation conditions
- the most favourable organization for detecting discontinuities. To insure that all orientation discontinuities are detected, it is necessary to use at least two directions of magnetization which should preferably be perpendicular to each other.

Regardless of the process or processes chosen by the user, their efficiency will have to be demonstrated. A particular procedure may be requested by the Manufacturer.

3.2 MAGNETIZATION THROUGH THE PASSAGE OF MAGNETIC FLUX

3.2.1 - Magnetization by electromagnet (Yoke technique)

The use of this type of apparatus allows the control of finished surfaces.

The air gap between the poles and the part must be limited to a minimum to avoid magnetic leaks.

This mode of magnetization reveals discontinuities of which the significant dimension is perpendicular to the axis connecting the poles of the apparatus.

The electromagnet will necessarily be energized using an alternating current.

3.2.2 - Magnetization by coil and cable winding

The magnetization obtained through winding a cable around a part or a section of a part in order to create a coil allows the obtaining of high field value. (See 3.1.1) This mode of magnetization reveals discontinuities of which significant dimension is perpendicular to the axis of the coil.

3.3 MAGNETIZATION BY CURRENT PASSAGE

3.3.1 - Local magnetization by means of electrodes

This mode of magnetization reveals discontinuities, the significant dimension of which is parallel to the direction of the current.

Particular precautions must be taken during the use of this process which may severely damage the parts, particularly finished parts:

- The apparatus must be equipped with an opening and closing switch for the electric circuit in order to switch on the current only when the electrodes are in contact with the part so as to avoid parasitic arcing.
- The current intensity and the duration of magnetization must be determined in a way to limit, as much as possible, local overheating at the points of contact.
- The electrodes must be equipped with low friction metal tips.

3.3.2 - Overall magnetization by current passage.

This mode of magnetization reveals discontinuities, the significant dimension of which is parallel to the direction of the current.

Precautions must be taken to limit local overheating at the points of contact.

3.4 INFLUENCE OF THE NATURE OF THE CURRENTS

The electric currents used for magnetization through the passage of flux or through the passage of current in the part, have an influence on the performance of the magnetic particle inspection with the following characteristics:

- **Alternating current** : The eddy currents maintain the magnetic flux on the surface; slightly sub-surface discontinuities or discontinuities connected to the surface are detected very well regardless of the shape of the part.
- **Rectified single phase current, one alternation (R1A)**: This mode is an intermediate one between the alternating and direct currents.
- **Rectified single phase current, two alternations (R2A)** : It is related to direct current and is convenient for parts of simple configuration. It allows a deeper detection depending of the dimensions of the discontinuities.

4 - INSPECTION MATERIAL

4.1 CURRENT GENERATOR

Generators are used for magnetization through passage of current (generally in the part or locally by means of electrodes) or for magnetization by the passage of flux (use of wire coils). They must be able to supply high intensity current at low voltage.

The currents supplied may be:

- alternating
- rectified one alternation
- rectified two alternations.

These devices and their instrumentation, if any, must be verified periodically using modalities defined by the user.

4.2 ELECTROMAGNETS

Portable electromagnets are used to produce local magnetization through the passage of flux. These devices must be verified periodically in order to make sure that they can lift a ferritic mass of 4.5 kg with a distance of 150 to 200 mm between poles.

4.3 TYPES OF AGENTS

Agents consist of fine grain ferromagnetic powders of low residual magnetism which may be used dry (dry powder) or in a liquid suspension (liquid ink).

These magnetic powders exist in two types:

- magnetic powders of which their own colour is used (grey or blue depending on their nature).
- magnetic powders with composite grains with a ferromagnetic core coated with a pigment which is visible either under white light or under ultra-violet rays.

The agents used must have a granular concentration and a colour to insure adequate sensitivity and contrast for the use for which it is intended. The concentration of liquid inks in magnetic powder is the one prescribed by the supplier. It may be verified for indication purposes using the ASTM pearshaped tube. It is generally of 1.2 to 2.4ml/l concentration for black inks and 0.1 to 0.4 ml/l for fluorescent inks.

The efficiency of the product used will be checked using a test piece placed on the part being inspected (Berthold, AFNOR or ASTM test piece for instance, see § 4.4).

The Quality Sheet will specify the product to be used.

4.4 METHODS FOR VERIFICATION OF THE MAGNETIZATION CONDITIONS

The magnetization conditions as well as the quality of the indicators can be checked using a magnetization test piece AFNOR, Berthold or ASTM. Nevertheless, it should be noted that the appearance of an indication on a test piece is not a sufficient element to judge the state of magnetization of the examined piece. The real conditions of magnetization can only be verified by means of a Hall probe to measure the tangential magnetic field.

5 - OPERATING METHODS

5.1 CHOICE OF THE MAGNETIZATION METHODS

The choice of magnetization method is dependent on the geometry, the steel grade and the finishing condition of the parts to be inspected. It is determined as well by the orientation, and the presumed depth of the discontinuities sought. Combinations are possible.

The methods chosen must allow for a magnetization in two directions, mostly at right angle to each other and must meet the requirements of § 3.

5.2 MAGNETIZATION USING ELECTROMAGNETS (YOKE TECHNIQUE) OR PASSAGE OF CURRENT BY MEANS OF ELECTRODES (PRODE TECHNIQUE).

To facilitate the control of large parts through local magnetization, the surfaces can be marked out in squares in elementary areas using chalk. The poles of an electromagnet (fig. 1) or the electrodes (fig. 2) are placed as shown in the following examples:

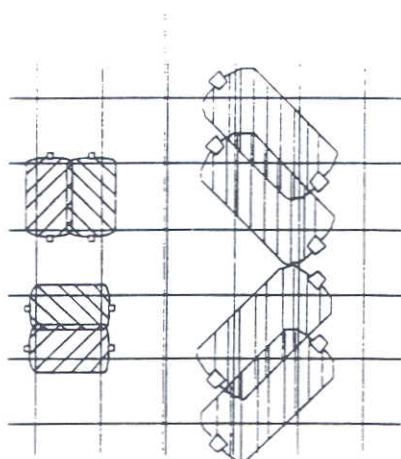


Figure 1

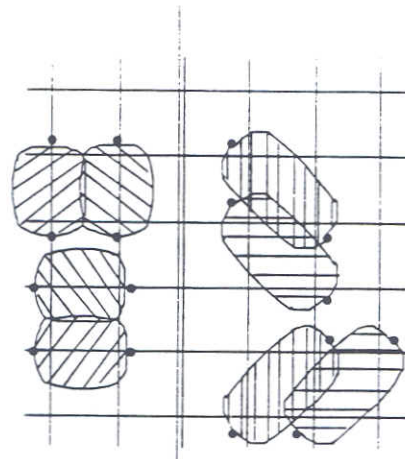
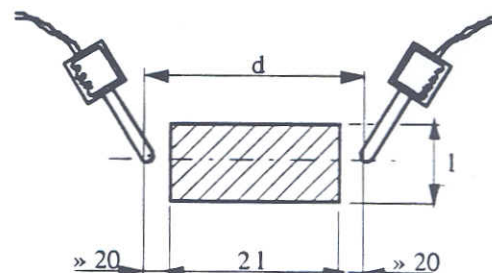


Figure 2

The dimensions of the squares must be such that the distance between the poles or the electrodes and the recovering of the successive magnetized surfaces allow to insure at all the points of the examined area a tangential magnetic field in conformity with § 3.3.1.

If no field measuring equipment is available, the magnetization condition is fulfilled, if a effective intensity of current 50 A per cm of distance «d» between the electrodes is obtained; the elementary inspected area for each position will be that defined by the illustration shown in the margin.



For certain ferromagnetic stainless steels, the intensity of current has to be raised; values of about 70 A /cm may be necessary.

5.3 APPLICATION OF AGENTS

5.3.1 - Use of dry powders (limited to classes 3 to 5)

The surfaces examined must be completely dry. The magnetic powder spread over the area should be made up of a fine uniform coating by adequate means during magnetization. While maintaining the magnetization, the excess of powder should be blown off carefully so as to leave only the indications created by the discontinuities.

5.3.2 - Use of magnetic inks

The magnetic ink will be applied by flowing or preferably by spraying over the examined area during magnetization.

Magnetization must be maintained for a while after the liquid has been applied, so that the indications can stabilize and in order not to alter the already formed indications.

It is important to insure the homogeneity of the ink.

5.4 CONDITIONS OF OBSERVATION OF MAGNETIC INDICATIONS

Visual observation of the magnetic indications should be carried out with the naked eye or under slight magnification (maximum 3 fold). For an examination under white light the area examined must be lit with natural or artificial lighting corresponding to at least 500 lux.

In case fluorescent products are used, the part or area examined must be located in a dark area, where the level of white light will not exceed 40 lux. Observation is made under ultra-violet light of at least 800 $\mu\text{w}/\text{cm}^2$ of intensity (ASME code, sect. V).

5.5 INTERPRETATION OF RESULTS

Discontinuities are revealed by a concentration of the ferromagnetic particles of the agent, showing leaks in the magnetic field.

However, all visible indications don't necessarily correspond to defects, false indications may be caused by any of the following:

- Irregular geometry (change of section)
- Excessive roughness
- Excessive variation in magnetic permeability (welds, local peening etc...)
- Excessive intensity of magnetic field
- Excessive remanent magnetization..

In case of doubt supplementary investigations must be carried out after having modified the examination conditions (improvement of the surface condition, modification of the conditions of magnetization, etc...).

6 - ACCEPTANCE CRITERIA

The indications taken into account are the ones that are, in mutual agreement, considered as a defect and not to a surface particularity or a structural discontinuity (see § 5.5).

The acceptance criteria for each class are listed in the following table :

Table 2

Nature of defects	Quality classes	Max. dimensions of indications or n° of ASTM E 125 reference standard				
		1 (1)	2	3	4	5
Threshold of accountability (in mm)		0,5	1	1,5	2	3
Linear discontinuities	(2) non admitted					
- Maximum length of indications	-		3 mm	5 mm	10 mm	15 mm
- Maximum total sum of indications length on Σ (3)	-		18 mm	30 mm	60 mm	90 mm
- Minimum distance between the ends of two aligned indications (4)	-		10 L	8 L	5 L	4 L
Porosities	non admitted					
- Maximum length of indications	-		3 mm	5 mm	5 mm	5 mm
- Ratio: sum of indications surface / Σ	-		2 ‰	5 ‰	10 ‰	20 ‰
- Minimum distance between the edges of two neighbouring indications	-		9 mm	15 mm	15 mm	15 mm
Superficial shrink holes (5)	non admitted		n° II-1	n° II-2	n° II-3	n° II-4
Inclusions (5)	non admitted		n° III-1	n° III-2	n° III-2	n° III-3

- (1) **Classe 1** =Special class (highly stressed, critical areas, for example areas to be welded)
Concentrations of numerous small indications, even of pin holes, will lead to a grinding of the surface in question to examine the evolution of the indications : in case the indications tend to lengthen and to rejoin one another, the affected area will be repaired.
- (2) Cracks and lack of fusion are not acceptable in class 1.
- (3) Σ : Reference surface identical with the surface of the reference photographs shown in ASTM standard E 125 i.e. approx. 100 x 160 mm.
- (4) L : Length of the longest indication.
- (5) In case of disagreement and if the nature of the defect cannot be identified, the indication will be considered to be a linear discontinuity.

7 - CLEANING - DEMAGNETIZATION

7.1 CLEANING

At the conclusion of the examination, the residual products are to be removed using adequate cleaning products.

7.2 DEMAGNETIZATION

Demagnetization of the parts may be requested by the Manufacturer, who will specify on the Quality Sheet the admissible residual magnetization.

As a reference, residual magnetization of less than 600 A/m (8 Oe) will eliminate any problems with adhering chips.

8 - INSPECTION REPORT

The inspection report must indicate :

- Identification of the Founder, the Manufacturer or the Designer
- Identification of the casting (heat Nr - traceability)
- Steel grade of the casting
- Designation of examination documents used : reference to the present specification, Quality Sheet...
- Stage of manufacture at inspection
- Mode of surface preparation
- Mode of magnetization, the device used, type of current, nature of the revealing agent
- Examination conditions
- Areas inspected
- Inspection results
- Name, signature and certification of inspector
- Identification of the firm in charge of the inspection if sub-contracted
- Date of inspection and signature of the responsible person for inspection.

TECHNICAL SPECIFICATION FOR ULTRASONIC INSPECTION

0 PREAMBLE

The ultrasonic examination of cast steel parts allows the detection of possible internal defects and to estimate as far as possible, their nature, their dimensions and their position in the section under examination.

The inspection method described in this technical specification is based on the reflection of ultrasonic waves produced by a defect or the opposite surface of the part and is visualized by an echo on the screen of the apparatus (method of echo pulse ultrasonic testing).

The operator manually shifts the probe by applying it on the surface to be inspected which is covered with couplant (contact technique).

The choice of the probe depends on various parameters (geometric shape of the parts, acoustic permeability to ultrasound, type of defects sought).

For this research, the types of probes that are available are:

- a) Standard longitudinal wave probes.
- b) Standard transverse wave angle probes.
- c) Probes with separate transmitter and receiver (SE type) for longitudinal wave or angle probes for transverse wave.

0.1 PART 1 : LONGITUDINAL WAVES EXAMINATION

This ultrasonic examination using normal longitudinal wave probes with flexible membrane is applied in most cases to identify and locate defects in steel castings.

0.2 PART 2 : TRANSVERSE WAVES EXAMINATION

This ultrasonic examination, which uses transverse wave angle probes is more specific to control areas assembled or repaired by welding, for characterisation of indications and for controls of weld ends...

The examination must be specified in the Quality Sheet or in the technical specification of the Designer (probe used, areas to examine, acceptance criteria) and must be defined during the call for tender and placement of the order. ◆

In the absence of specification, the founder will use the technique described in part 1.

Note :

- *Ultrasonic inspection has its limitation and can only give an indication of the type of defect revealed by the ultrasonics.*
- *Ultrasonic inspection and radiographic inspection do not supply indications which are directly comparable.*
- *For the ultrasonic inspection of the cast steel parts of austenitic or austenoferritic (Duplex) steels, special measures must be specified by the parties involved.*
- *The application of longitudinal wave angle probes is not considered in this specification.*

PART 1

LONGITUDINAL WAVES EXAMINATION

1.1 OBJETIVE AND FIELD OF APPLICATION

This specification outlines the measures to be implemented for ultrasonic inspection of ferritic or martensitic steel castings, whose thickness varies between 10 and 600 mm. For parts under or over these limits, the control method must be defined by the parties involved.

Its purpose is to detect possible internal defects in the parts, to designate the indications and to define the acceptance criteria.

It applies to the pulse echo ultrasonic testing with longitudinal waves (normal longitudinal wave probe).

1.2 METHODS USED

The methods described in this specification are :

- either plot a «Distance Amplitude Curve» (**DAC**) from the deflection of longitudinal waves obtained on flat bottom holes on reference blocks.
- or use the existing reference diagrams (**AVG** method).

The choice of either of these methods for inspection of parts will be specified in the Quality Sheet.

The normal longitudinal probe is manually displaced on the surface of the part to be examined. Internal discontinuities resulting in the appearance of a pulse echo and/or the decrease of the back echo when this back echo can be obtained in an area having parallel surfaces, are analysed while considering size, amplitude, position and the nature of the defect. The results obtained are compared to the criteria of acceptability.

1.3 ULTRASONIC INSPECTION MATERIAL

1.3.1 APPARATUS

Characteristic of the apparatus :

- The pulse generator will allow the performance of tests at frequencies varying between 1 and 5 MHz using standard probes or separate transmitter/receiver type probes.
- Visualization is of type A.
- The apparatus will be equipped with a calibrated amplification control ,graduated in dB, adjusted by increments of at least 2 dB.

The verified characteristics are :

- The linearity of the amplification: The difference will be less than ± 2 dB over the entire scale used.
- The time base linearity or the horizontal linearity: The difference should be less than 2% of the measuring range.
- Vertical linearity: In the absence of a threshold the difference should not exceed 5% of the height of the screen.

All these verifications should be made for each generator:

- Upon its purchase
- After repair
- At least once a year.

A calibration report is produced. Every apparatus must have a label indicating the date of calibration validity.

1.3.2 PROBES

The nominal frequency of the probes and the dimensions of the piezo-electric chips are chosen subject to the nature, the dimensions and the geometry of the part to be examined and the type of defect sought. The recommended frequency is 2 MHz.

One can use either of the following two longitudinal wave probes:

- Standard longitudinal wave probe

These probes are often used with a flexible protective membrane. The dead zone must be as short as possible.

- Separate transmitter and receiver probes (twin probe)

These are recommended for the detection of surface defects and defects in thin parts ≤ 50 mm. The converging area of these probes with separate transmitter and receiver must be adapted to the inspection to be performed.

The methods of use are specified in the Quality Sheet. In the absence of specific indications, a standard longitudinal wave probe will be used.

1.3.3 OPERATIONS TO PERFORM DAILY ON THE APPARATUS AND AT EVERY CHANGE OF SHIFT

- Verification of physical condition and external appearance of the apparatus (pulse generator, probe, cable).
- Quick verification of the calibrated amplifier.
- Verification of sensitivity and of the resolution power of each probe used.

a) Sensitivity

A plastic insert from the international calibration block IIW A2 will be used.

The number of visible echoes on the oscillogram, set at the maximum gain if necessary, should not be less than the number indicated on table 1 for the frequency range chosen with a standard longitudinal wave probe of 20 to 26 mm in diameter.

Table 1
Minimal number of echoes

Frequency range MHz	Minimal number of echoes
0,5 to 1,3	5
> 1,3 to 1,8	4
> 1,8 to 2,6 (*)	3
2,7 to 5,0	2

(*) Recommended range

b) Resolution power

The depth resolution must be assessed for the complete control apparatus (apparatus-cable-probe) by measuring the width of the first back echo using the 25 mm section of the basic steel calibration block IIW A2.

The amplitude of the echo must be set at 80 to 100% of the total height of the screen and the width of the echo must be measured in mm of steel at a value of 10% of the height of the echo. Table 2 gives the characteristic values:

Table 2
Characteristic values

Frequency MHz	Width of the echo longitudinal waves mm
1	15
2 or 2,25	9
4	5
5	4

1.3.4 COUPLANTS

May be used as couplants:

- Couplant pastes
- Oils
- Greases
- Cellulose glues diluted with water

The efficiency of the couplant used will be verified by obtaining one or several stable back echoes on parallel surface areas. This same couplant should be used for any adjustment and for all subsequent inspection operations.

The Designer may specify in the Quality Sheet the particular type of couplant to use.

1.3.5 REFERENCE BLOCKS

The reference block or blocks are used to establish the distance amplitude curve (DAC). These blocks are made of cast steel and present the acoustic characteristics which are similar to the material to be inspected.

The difference of the fading of the ultrasonic signal between the reference block and the part to be inspected will be examined (see § 1.4.5).

Reflectors are flat bottomed holes of 6 mm (+ 0.4/-0) drilled perpendicular to the surface to be inspected. A set of reference blocks must include at least 4 flat bottomed holes chosen in a scale of 25-50-75-150-250 mm. For inspection of parts of more than 380 mm, one or several extra blocks of defined thickness relative to the order are added to the basic set. The dimensions of the reference blocks will be based on the ASTM A 609 standard or other equivalent standards.

Each block must be identified permanently on the side through its identification and steel grade.

1.4 INSPECTION CONDITIONS

1.4.1 STAGE OF INSPECTION

Ultrasonic inspection is always carried out after quality heat treatment.

1.4.2 AREAS TO BE INSPECTED

The area or areas to be inspected and the extent of inspections are specified in the Quality Sheet..

- **100% ultrasonic testing** symbolized by an **X** on the Quality Sheet in the space corresponding to the area in question. The probe is shifted along parallel lines with recovering so as to examine the entire area successively.
- **Spot check inspection** symbolized by QL, QP or SL.

QL followed by a number: The probe is shifted along the lines of a squared or chequered area; the number following the symbol indicate the squaring pitch in mm.

QP followed by a number: The probe is placed successively over each intersection of lines as described above.

SL the probe is shifted along lines defined for each case.

For spot check inspections the following regulation will be applied :

- To avoid the application of the clause mentioned in § 4 of the «INTRODUCTION», the Designer is to define clearly, at the latest when passing an order, the exact location of the intersection of the lines. ◆
- If a defect is revealed its extent will be determined by inspecting the adjacent areas.
- The guarantee for a quality class specified being met on the entire area under examination depends on the squaring pitch and on the acceptance criteria required.

1.4.3 SURFACE PREPARATION

The Quality Sheet will prescribe the surface finish required for the inspection considering the acceptance criteria and the probes used.

The surfaces to be inspected on steel castings must be such that the couplants between the probe and the part will not have a significant influence on the sensitivity of the examination.

The surfaces should be without ondulations which could hinder the contact between the probe and the part. The surfaces to be inspected must be free of rust, scales, weld spatter or other irregularities which would interfere with the transmission of ultrasonic waves or the movement of the probe.

The surface finish must at least correspond to samples 2S1 (for surfaces cleaned by sand or shot blasting) or 3 S2 (for ground surfaces) of the BNIF standard or subject to SCRATA A1 (for sanded surfaces) or H1 (for ground surfaces).

In general a surface finish corresponding to reference N10 (12.5,µm) as per ISO 1302 is acceptable. In case a separate transmitter receiver probe is used, the surface finish shouldn't be greater than 2S2 ($Ra \leq 6.3 \mu m$).

1.4.4 ADJUSTMENT OF THE SPEED OF SWEEP

By adjustment of the horizontal sweep the maximum distance between the transmission point of the pulse and the most distant possible echo should be obtained considering the adjustment limits of the apparatus. For calibrations only the distances between multiple echoes or between two echoes corresponding to distant reflectors of a known value may be used and not the distance between the pulse transmission and the first echo.

The way, the relative position of an echo is located on the screen permits to determine the depth of the corresponding reflector.

1.4.5 ADJUSTMENT OF AMPLIFICATION AND INTENSITY

1.4.5.1 Use of reference blocks: (DAC Method)

The adjustment of amplification and intensity is carried out on indications obtained from artificial reflectors (cylindrical holes with flat bottom of the reference blocks). These adjustments are carried out simultaneously, the amplification threshold being brought back to the minimum. During these adjustments the intensity must be maintained as low as possible, the height adjustment of the reference echoes is obtained only through the adjustment of amplification.

Correction of ultrasonic energy absorption.

To consider, to a certain extent, possible differences in surface finish and or absorption of ultrasonic waves between the casting under inspection and the reference block, the amplification can be modified as follows:

- Place the probe in an area of the casting which has parallel surfaces and whose thickness is equivalent to that of the block and whose surface finish and preferably whose internal structure are representative of the rest of the casting.
- Place successively the probe on the reference block (outside the area with artificial reflectors) and on the casting to be inspected.

Are to note :

- The two gains necessary to bring the back echo to a similar screen height.
- The difference in gain g_1 indicates the necessary increase in gain in correction of ultrasonic energy absorption.

The gain to be used for inspection corresponds to the gain used for establishing the distance amplitude curve, increased by g_1

In practice, this correction is made only if $g_1 > 2\text{dB}$

Adjustment based on indications obtained from artificial reflectors of the reference block

Two modes of adjustment may be used:

a) Distance amplitude curve (DAC)

The probe is placed in a way to obtain the maximum pulse echo on the reflector giving the strongest pulse and the adjustment is made so as to bring its amplitude to 80% approx of the height of the screen.

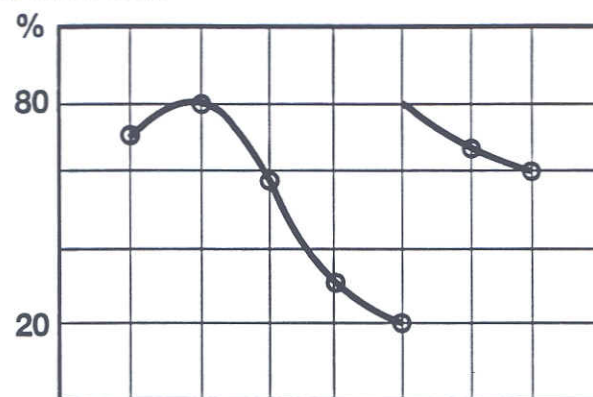
The maximum amplitude of the echoes received on each of the other reflectors is noted. The curve joining these points constitutes the distance amplitude curve. Except in the case of small thicknesses, this curve is plotted with a minimum of 3 points.

If the amplitude of the echo received on one reflector is less than 20% of the height of the screen, a fractionated distance amplitude curve will be plotted as indicated in figure 1.

A new adjustment is made so as to bring the amplitude of this echo to approximately 80% of the screen height.

b) If the apparatus used allows it, the distance amplitude curve may be replaced by a **diagram of the amplification values** necessary to bring the amplitude of the echoes on each reflector at the same height (approximately 80% of the screen height).

Figure 1 : Distance amplitude curve DAC



1.4.5.2 Use of existing reference diagrams : AVG Method (DGS method)

The AVG method is similar to the DAC method in so far as the objectives are concerned but it doesn't require artificial reflectors for plotting.

For most of the standard probes and for probes with separate transmitter / receiver, the manufacturers suggest using abacus type AVG screens which are placed on the apparatus screen (respectively electronic curves on digital equipment).

The abacus screen remains valid only if probes of the same type have similar characteristics. Acoustic absorption resulting from the material must not be neglected and the method of correction of ultrasonic energy absorption described in the DAC method is applicable. The adjustment of sensitivity is obtained from the reference echo which is brought to the screen of the ultrasonic apparatus to a given reference height.

1.4.6 FREQUENCY OF VERIFICATION OF THE ADJUSTMENTS

These adjustments must be made at the beginning of each inspection sequence and must be verified at the beginning and at the end of each shift and every time the operator suspects a drift in the installation.

Every verification is considered adequate if the drift noted stay smaller as ± 2 dB. Otherwise, the inspection must be carried out again as of the previous verification.

1.5 METHOD OF SEARCHING FOR DEFECTS

In all the areas that have to be 100% inspected, the operator must carry out a complete sweep making sure that there is a systematic recovering of at least 10% of the probe diameter.

The speed of shifting of the probe must be adapted to the examination conditions and must not exceed 150 mm/s.

The search for defects is made with an adjustment corresponding to as great a sensitivity as possible considering the electronic noise (grass) (approximately + 6dB).

INDICATIONS TO BE INVESTIGATED:

The indications to be investigated are:

- Intermediate echoes,
- Any back echo attenuation which is not explicable by the geometry of the casting.

Sometimes certain indications are impossible to interpret or may let presume the presence of flat defects as for example cracks. These indications will be considered to be «indications to be confirmed» (see § 1.8) in particular for areas in which significant repairs have been made.

1.6 CHARACTERIZATION OF INDICATIONS

1.6.1 LOCATION

The indications are localized relative to a known and defined system of marking.

1.6.2 DIMENSIONING OF INTERMEDIATE ECHOES OBTAINED

1.6.2.1 Dimensioning in amplitude from the distance amplitude curve (DAC) obtained over the flat bottomed holes.

- a) If the distance amplitude curve is used in conformity with § 1.4.5.1a the maximum amplitude of the indication is compared to the ordinate of the curve for the same sonic path and in the same conditions of adjustment used for its establishment. The extent of the defect is expressed in percentage of the distance amplitude curve.
- b) If the adjustment is made in conformity with the methods defined in § 1.4.5.1b, having determined the depth location of the indication, the adjustment is compared to the indication obtained for the artificial reflector which is the closest and whose amplitude is taken as a reference. The extent of defect is expressed as a percentage of the reference amplitude.

1.6.2.2 Dimensioning of amplification using the AVG method

The maximum amplitude obtained on the indication is compared to the AVG abacus curves for the same sonic path and in the original adjustment conditions. The degree of the indication is expressed in equivalent diameter

1.6.2.3 Dimensioning of indications

- **Indications which can be measured in surface**

The dimensioning involves demarcating the defects noted. The outline of the defect is defined by the positions of the centre of the probe corresponding to an amplitude of the echo equal to half of the maximum amplitude of the echo of the defect being inspected (the -6 dB method). This demarcation is made with the same probe or with a similar type probe in the same operating conditions used to detect the defect.

This demarcation requires the prior marking of the defects upon their detection. To demarcate the defect, the probe is shifted in all directions over the probed surface. The outline of the defect defines the surface S of this defect; the length of the defect is the largest dimension of the whole defect.

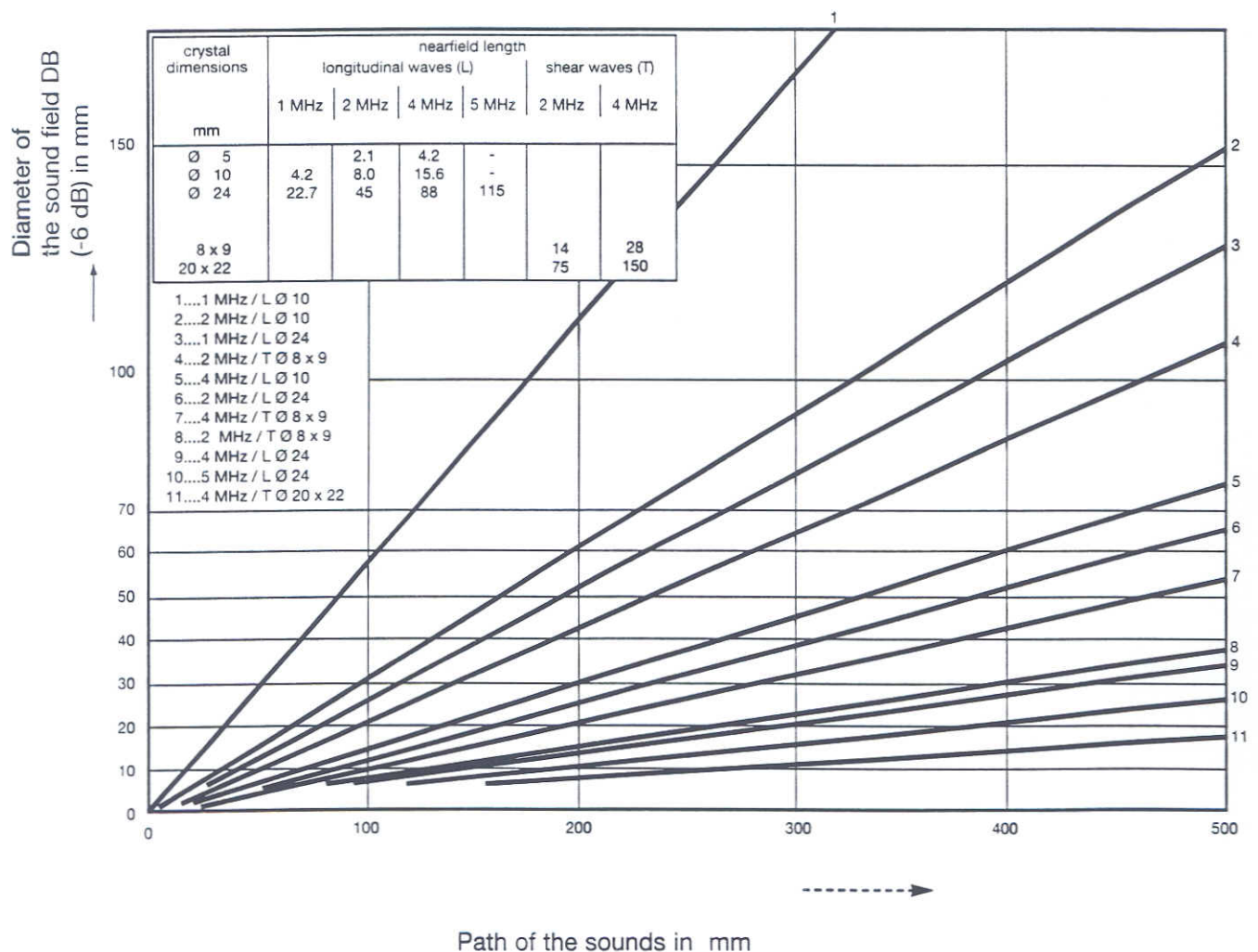
Note :

If the investigated surface is not relatively flat, determining the real surface of the defective area may require a sketch.

• **Indications which are not measurable in surface**

If the dimension of the indications is inferior or equal to the diameter of the ultrasonic beam, the indication is described as non measurable in surface. The following graph which is taken from the Euronorm CEN/TC 190 N224: 1993 (Figure 4) will be helpful .

The indications non measurable in surface will be evaluated as per §1.7«ACCEPTANCE CRITERIA».



Approximate values of the length of the near field and the sonic beam diameter (-6dB) in the far field of the monocrystal standard probes based on the sound path (represented by curves 4,7,8 and 11 for angle probes). It is the smallest of the two axes of the elliptical sonic field.

1.6.3 DIMENSIONING RELATIVE TO THE DECREASE IN BACK ECHO

1.6.3.1 Dimensioning in amplitude

Any area in which a decrease in back echo is noted is characterized by the formula

$$\frac{\Delta F}{F_0} \quad \text{where } \Delta F = F_0 - F$$

F_0 = Height of the back echo in a sound area with parallel walls of similar thickness as the area to be examined.

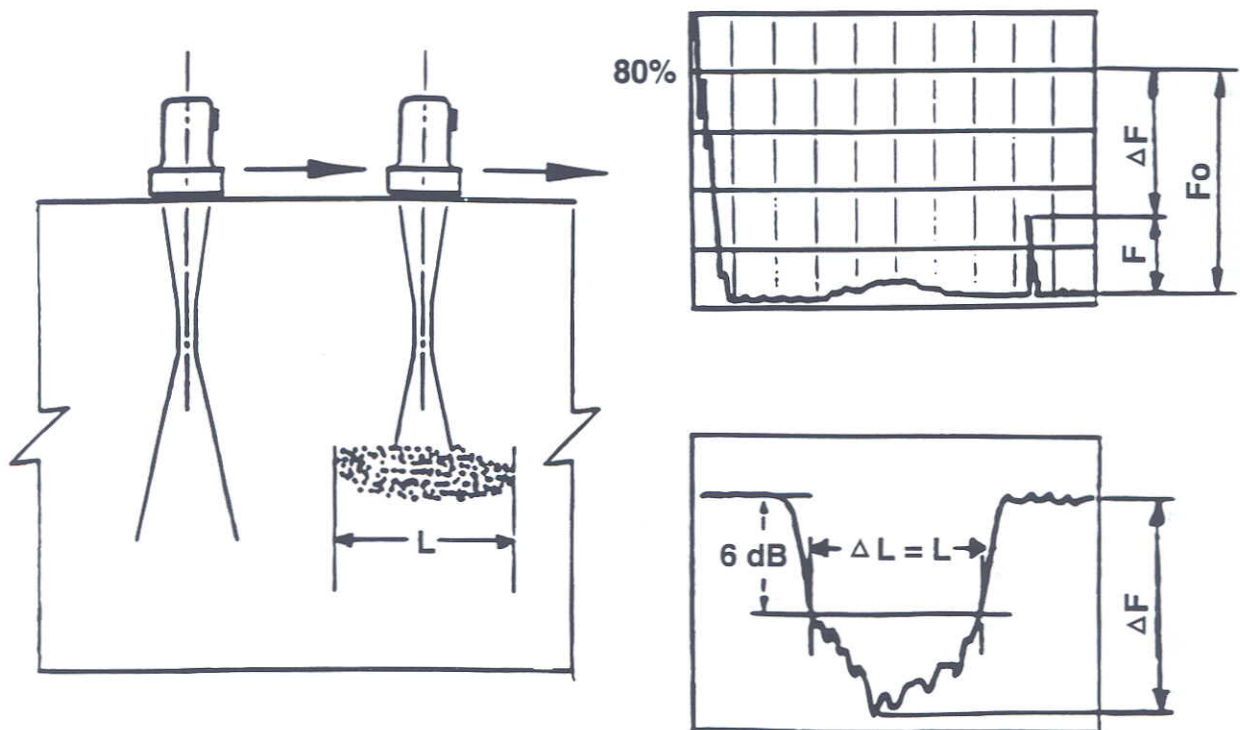
F = Height of the back echo in the examined area with parallel walls.

1.6.3.2 Dimensioning in geometry

F_0 is brought to a height of approximately 80% of the height of the screen.

The dimensioning involves the demarcation of the loss of back echo ΔF . The outline of the loss of the back echo is defined by the positions of the centre of the probe corresponding to ΔF maximum, minus 50% (see Figure 2). For each new position of the probe, the position of the beam axis is marked; the outline obtained by joining the positions of the beam axis defines the S surface of the defective area.

Figure 2 : Demarcation of the loss of back echo

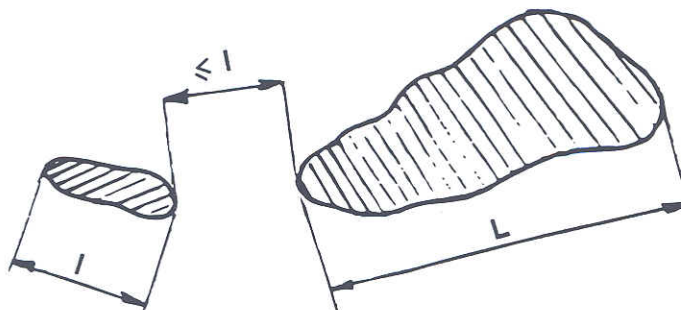


Dynamics of the loss of back wall-echo

1.6.4 CUMULATED INDICATIONS

Two neighbouring defects must be considered as constituting only one defect, of equal surface to the sum of both, if the distance which separates their outline is equal or less than the largest dimension of the smallest defect (figure 3).

Figure 3 : Cumulation of 2 neighbouring indications



1.7 ACCEPTANCE CRITERIA

The acceptance criteria may cover the height of the flow echo (defect echo), the equivalent diameter AVG, the attenuation of back echo, the number of non measurable indications, the surface of each elementary area, the total surface of the cumulated elementary areas.

Indications which exceed the acceptance criteria limits may be repaired or may «require confirmation»; the decision in this regard will be left to the Designer (see § 1.8).

Definitions

D Height of the maximum echo on the defect after return to the calibrated amplification.

R Height of the reference curve at the same depth.

F Height of the back echo in the inspected area with parallel surfaces

F_o Height of the back echo on the sound area with parallel surfaces, of the same thickness as the area to be inspected.

$$\Delta F = F_o - F$$

S Surface of the elementary areas obtained by grouping «indications to be recorded» applying the method described in § 1.6.2.3. et 1.6.3.2.

() Numbers 1 to 9 between the parentheses indicate that one should refer to the legend at the end of §1.7, page 56.

Table 3 sets for both the DAC and AVG methods, the classes of quality 1 to 6 in order of decreasing severity, the notation threshold, the area of consideration of the indications and the attenuation of the back echo. Tables 4 and 5 set the maximum admissible indications.

In a same section, the Designer can determine several classes of severity. The repartition of the areas subject to the thickness of the part can be defined according to the legend (9). In this case the Designer stipulates on the Quality Sheet in the area considered for example :

ZONE IV Rz = Classe 2 where Rz = rim zone see fig. 5 (page 57)
Cz = Classe 4 Cz = core zone

Table 3
Threshold for notation

Class	AMPLITUDE							
	Notation threshold				Area of consideration			
	DAC Method	AVG Method	Back wall echo attenuation		DAC Method	AVG Method	Back wall echo attenuation (3)	
	$\frac{D}{R} \geq$	$\emptyset$ equivalent (mm) $\geq$	$\frac{\Delta F}{F_0} \geq$	% $\geq$	$\frac{D}{R} \geq$	$\emptyset$ equivalent (mm) $\geq$	$\frac{\Delta F}{F_0} \geq$	% $\geq$
1 (5)	0,15	2	0,25	25	0,25	3	0,25	25
2 (5)	0,25	3	0,25	25	0,50	4	0,25	25
3	0,25	3	0,5	50	1	6	0,5	50
4	0,5	4	0,5	50	1,8	8	0,5	50
5	0,5	4	0,5	50	3	10	0,75	75
6	0,5	4	0,5	50	4	12	0,75	75

() See page 56

Table 4

NUMBER OF LOCALIZED INDICATIONS (2) (indications not mesurable in surface)

Maximum acceptable density per dm² based on the area considered defined in Table 3 (4)

Class	DEPTH INVESTIGATION OR THICKNESS OF THE STEEL CASTING IN THE CONTROLLED AREA (mm)				Acceptable distance between 2 indications $\geq$ mm
	≤ 50	$> 50 \text{ à } 100$	$> 100 \text{ à } 250$	$> 250 \text{ à } 600$	
1 (5)	3	4	5	6	12
2 (5)					
3					10
4					
5					
6					8

() See page 56

Table 5

MESURABLE INDICATIONS IN SURFACE ⁽⁶⁾

Limits of acceptance based on the area considered defined in Table 3 ⁽⁴⁾

DEPTH OF INVESTIGATION OR THICKNESS OF THE STEEL CASTING IN THE AREA INSPECTED												
Class	≤ 50 mm			> 50 to 100 mm			> 100 to 250 mm			> 250 to 600 mm		
	Individual S Surface (cm ²)	cumulated S Surface (cm ²) (7)	Extension in depth % (8)	Individual S Surface (cm ²)	cumulated S Surface (cm ²) (7)	Extension in depth % (8)	Individual S Surface (cm ²)	cumulated S Surface (cm ²) (7)	Extension in depth % (8)	Individual S Surface (cm ²)	cumulated S Surface (cm ²) (7)	Extension in depth % (8)
1 ⁽⁵⁾	AVG Method Ø equivalent to< 3 mm or DAC Method D/R < 0,25								non acceptable			
2 ⁽⁵⁾	1	5	2	2	15	5						
3	2	25	10	3	35	10	15	100	10	40	200	10
4	8	50	15	12	100	15	25	150	15	60	300	15
5	15	100	20	25	150	20	40	200	20	100	350	20
6	20	200	20	30	250	20	50	300	20	200	400	20

() See page 56

LEGEND for tables 3, 4 and 5

- (1) Cracks are unacceptable.
- (2) When the dimension of the indication is smaller than the diameter of the ultrasonic beam, it is recommended to use an SE probe (separate transmitter receiver) or a probe whose limit of the near field is $\leq$ than the distance in depth of the defect.
- (3) The indications with a diminishing back wall echo of $> 50\%$ and/or with an attenuation of the back wall echo without the appearance of defect echo in the area of consideration and of surface superior to that indicated in Table 5, will be the subject of further investigations (see § 1.8 Indications to be confirmed).
- (4) Any accumulation of amplitude indications included between the threshold of notation and the area of consideration must be considered as an indication «to be confirmed» see § 1.8.
Acceptability of repair decisions will be taken on a case by case basis.
Isolated indications which seem to originate from several defects located at different depths will be considered as multiple indications.
- (5) Classes 1 and 2 are reserved for exceptional requirements determined by the Designer.
The inspection will be made using a probe with a separate transmitter receiver (of 4 MHz wherever possible) for thicknesses or depths ≤ 50 mm. Beyond those thicknesses or depths, use a standard perpendicular probe with a silence zone (dead zone) as short as possible.
- (6) The dimension of the indication is greater than the diameter of the ultrasonic beam.
The range is determined according to the - 6 dB method (see § 1.6.2.3).
- (7) It is the limit of acceptance of the sum of the elementary S surfaces, of the indications noted on an examined surface of 1000 cm² (approx. 32 x 32 cm).
- (8) The maximum acceptable extension in depth of the indication is expressed in % of the examined thickness (see figure 4).
- (9) Figure 5 indicates the distribution of areas in the thickness of a part.

Rz = Superficial areas (rim zone)
They are equal to 1/3 of the thickness of the part in its delivery condition with a maximum of 30 mm
Cz = Median area (core zone)
It is the area included between the two previous areas.

Note :

The demarcation between superficial and median areas is not always clearly defined when the casting is of complex shape. When discontinuities are located at the limits of these areas, consultation between the Designer and the Founder or Manufacturer is necessary.

Figure 4 :

Mesure of the depth extension of the defect
using a perpendicular probe

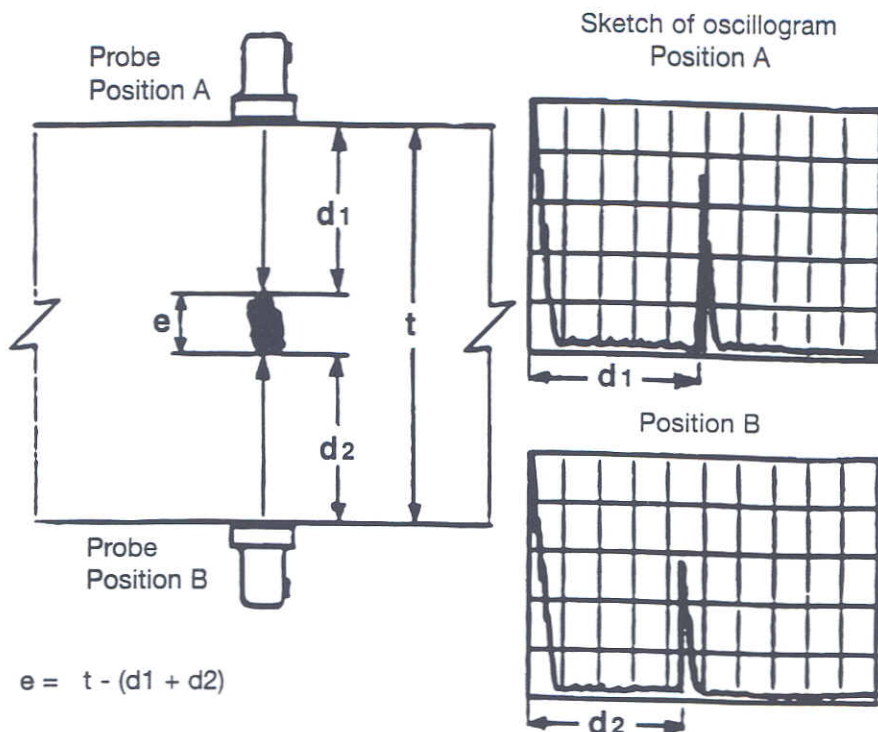
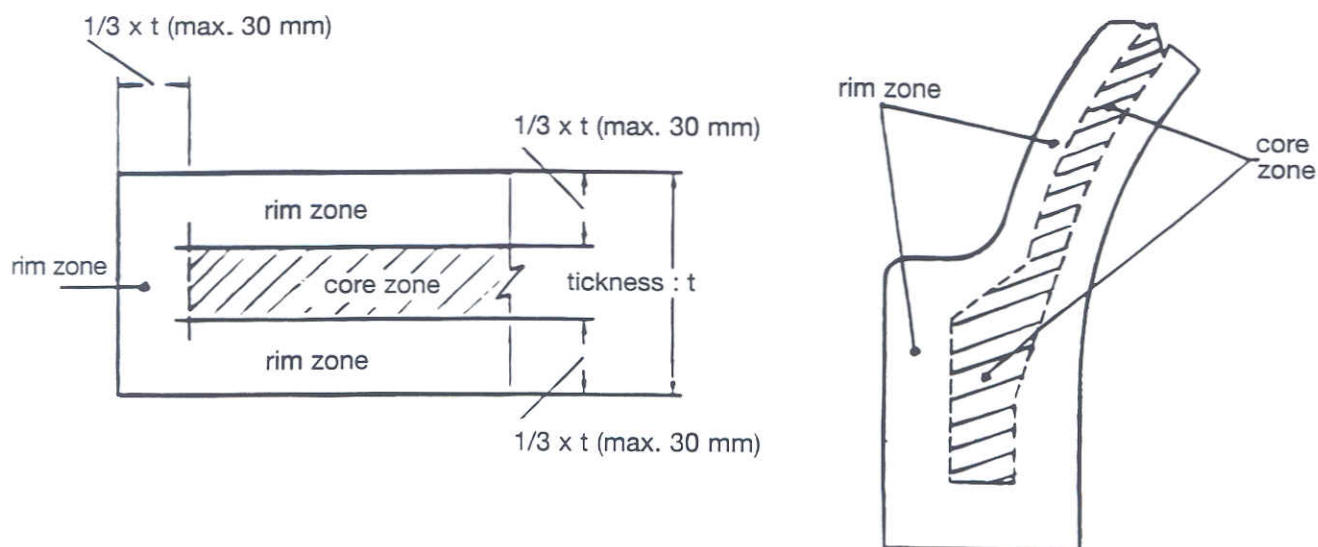


Figure 5 : Distribution of areas in the thickness of a part



1.8 INDICATIONS «TO BE CONFIRMED»

The indications «to be confirmed» will be the subject of additional investigations by using for example different types of probes so as to confirm or contradict the existence of a discontinuity and to indicate as much as possible the nature and the dimensions (see Part 2 - Inspection of transverse waves).

The Designer will decide, taking into consideration the degree of solicitation of the area in question as well as the possible evolution of the defect under service conditions.

If the Designer so requires, a detailed report with sketch will be established and transmitted to him.

If necessary and if the casting allows such inspection, confirmative radiographic inspection may be required, provided that the inspection criteria had been defined on the Quality Sheet when the order was placed. These criteria only apply to «indications to be confirmed» according to the present specification.

1.9 INSPECTION OF WELDED AREA (REPAIRS)

Unless otherwise agreed upon by the Designer, Founder and/or Manufacturer, repairs by welding will be inspected under the same conditions as those defined by the examination before repair.

However, the Designer may recommend that any «major» repairs be inspected as much as possible, so that repairs by welding be inspected using transverse wave probes (see Part 2 of the specification).

The methods of these supplementary inspections will be indicated on the Quality Sheet or in the Designer's Specification (areas to be inspected, methods used, criteria of acceptance) ◆

Definition of repairs considered «major» see chapter GE 70-3 § 5.1.2..

1.10 INSPECTION REPORT

The inspection report must indicate :

- Identification of the Founder or the Manufacturer or the Designer.
- Identification of the casting (heat number, traceability).
- Steel grade of casting.
- Designation of examination of documents used: reference to the present specification, Quality Sheet ...
- Stage of manufacture at inspection
- Mode of surface preparation.
- Trademark and type of apparatus and probe used.
- Conditions of calibration and adjustment.
- Areas inspected.
- Characteristics (position, amplitude, surface) of the indication $\geq$ the notation threshold.
- Inspection results.
- Name of the inspector, his signature and his certification.
- Identification of the firm in charge of the inspection, if sub-contracted.
- Date of inspection and signature of the responsible person for inspection.

PART 2

TRANSVERSE WAVES EXAMINATION

2.1 OBJECTIVE AND FIELD OF APPLICATION

This specification is applicable, after an agreement between the Designer, the Founder or the Manufacturer, for carrying out complementary investigations, for the characterization of indications, for inspection of weld ends, for the examination of welds, or of areas repaired by welding, for the inspection of welded joints between two parts. It defines the procedure to implement for ultrasonic inspection of ferritic or martensitic steel of more than 12 mm in thickness. It applies to the pulse echo method using transverse waves (angle probe).

2.2 METHODS USED

The methods described in this specification involve :

- either the plotting of a «Distance Amplitude Curve» (**DAC**) from the reflection of transverse waves obtained on the generator of holes drilled parallel to the contact surface,
- or using existing reference diagrams (**AVG** method).

The choice of either method for the part as a whole will be specified in the Quality Sheet. ◆

The angle probe is shifted manually over the surface of the part to be examined. Internal discontinuities causing an echo are analysed (dimensions, amplitude, position, nature of defect).

2.3 ULTRASONIC INSPECTION MATERIAL

2.3.1 APPARATUS

The apparatus is identical to the one used in longitudinal waves (see § 1.3.1).

2.3.2 PROBES

Transverse wave probes: The recommended refraction angles are 45°, 60° and 70°, the frequency used will generally be included between 2 and 5 MHz

2.3.3 OPERATION TO PERFORM DAILY ON THE APPARATUS AND EVERY CHANGE OF SHIFT :

- Verification of physical condition and external appearance of the apparatus (pulse generator, probe, cable).
- Quick verification of the calibrated amplifier.
- Verification of the direction of the beam in the vertical median plane of the probe (maximum squint angle 2°).
- Verification of the emergency point and the angle of refraction of the probe.
- Verification of the resolution power.

The depth resolution must be assessed for the whole apparatus (apparatus / cable / probe) through the measure of the width of the echo obtained on the basic quarter round of the steel calibration block IIW A2. The time base is adjusted on 50 mm full scale in the transverse waves. Knowing that 91 mm of steel permeated by longitudinal waves correspond to 50 mm of steel permeated by transverse waves, the apparatus is adjusted by placing a perpendicular probe on the 91 mm thick calibration block as per figure 6 position A. The perpendicular probe is replaced by the angle probe to analyse. It is placed on the calibration block as per figure 6 position B.

By adjusting the shift, one can see in the middle of the screen, the echo obtained on the calibration block quarter round (without changing scale).

The amplitude of the echo must be adjusted from 80 to 100% of the total height of the screen and the width of the screen must be measured in millimetres of steel at a value of 10% of the height of the echo.

Table 6 shows characteristic values.

Figure 6 : Verification of the resolution power

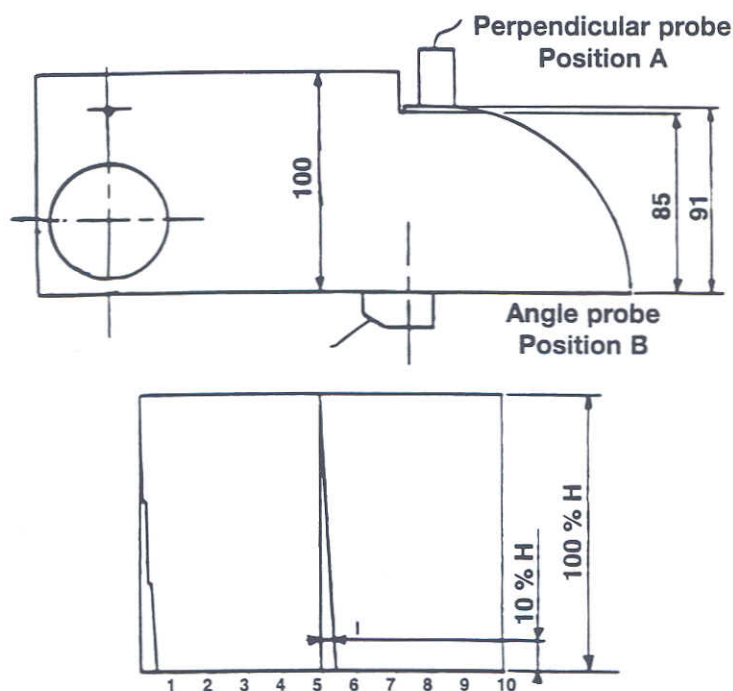


Table 6

Frequency MHz	Width of the echo Transverse waves mm
1	-
2 or 2,25(*)	5
4	3
5	2,5

(*) Frequency recommended

2.3.4 COUPLANT

The couplant used is identical to that used in longitudinal waves (see § 1.3.4).

2.3.5 REFERENCE BLOCKS (DAC)

The reference blocks are used to establish the Distance Amplitude Curve (DAC).

They are produced in a steel casting presenting acoustic characteristics as close as possible to the blocks used in longitudinal waves.

Under all circumstances, the attenuation difference of the ultrasound signal between the reference block and the part to be inspected will be verified (see § 2.4.5.1). The reflectors are made of holes drilled laterally at equal depths respectively at 1/4, 1/2 and 3/4 of the thickness of the reference block. The reference block dimensions will be produced in conformity with ASTM A 609, figure 4 and as indicated in table 7.

Table 7
Characteristics of the reference blocks in relation to thickness

Thickness to inspect «t» or depth of the excavation mm	CHARACTERISTICS OF THE REFERENCE BLOCKS			
	N°	Thickness «T» of the block mm	Location of holes	Diameter of the holes ± 0,05 mm
< 25	1	25 or t	1/2 T	2,4
> 25 to 50	2	50 or t	1/4 T - 1/2 T - 3/4 T	3
> 50 to 100	3	100 or t	1/4 T - 1/2 T - 3/4 T	5
> 100 to 150	4	150 or t	1/4 T - 1/2 T - 3/4 T	6
> 150 to 200	5	200 or t	1/4 T - 1/2 T - 3/4 T	8
>200 to 250	6	250 or t	1/4 T - 1/2 T - 3/4 T	10
> 250	7	t	1/4 T - 1/2 T - 3/4 T	(*)

(*) Above 250 mm, for each segment of 50 mm, increase the Ø of the hole by 1.6 mm.

Other types of reference blocks can be used.

These blocks shaped like a parallelepipedon have a series of cylindrical holes drilled from one end to the other, subject to the width of the reference block, parallel to the surface to be explored.

The diameter of these holes is a function of the thickness to be inspected (as per table 7).

- For a diameter equal to or less than 5 mm, the first hole will be drilled at 10 mm from the surface to be explored. The difference in depth between the next holes is of 20 mm.
- For a diameter greater than 5 mm, the first hole is drilled at 20 mm from the surface to explore. The difference in depth between the next holes is 40 mm.

Each block must be permanently identified on its side using its reference identification and its grade of steel.

2.3.6 REFERENCE DIAGRAM (AVG)

The AVG method is similar to the DAC method in so far as its objectives are concerned but it doesn't need any artificial reflectors for plotting. The reference diagrams proposed by the manufacturer for each type of probe is used (respectively electronic curves on digital equipment).

In the AVG diagrams, the relation between the length of the path of the sound waves and the amplification on the generating line of the circular section reflector, located perpendicular to the sound beam, is indicated as a parameter.

To determine the sensitivity of testing, the diameter of the circular section reference reflector is used, based on the thickness of the material to be tested.

Table 8
Circular section reference reflector $\varnothing$, in relation to thickness or depth

Thickness to control «t» or depth excavation mm	Circular section reference reflector Diameter in mm
≤ 25	2
> 25 to 50	2,5
> 50 to 100	3
> 100 to 150	4
> 150 to 200	5
> 200 to 250	5
> 250 to 300	6
> 300 to 400	7
> 400 to 500	8

2.4 INSPECTION CONDITIONS

2.4.1 STAGE OF INSPECTION

The ultrasonic inspection will always be performed after quality heat treatment, in case of inspection of repairs or construction welds, the inspection will be performed after the final heat treatment.

2.4.2 AREAS TO BE INSPECTED

The areas subjected to inspection and their range will be defined on the Quality Sheet if need be, subject to the following limitations. ◆

2.4.2.1 Welded joints or repairs

The area subjected to inspection should include the welding and the area adjacent to it, based on the three examples in figures 7, 8 and 9.

Figure 7 : Full penetration weld between two parts

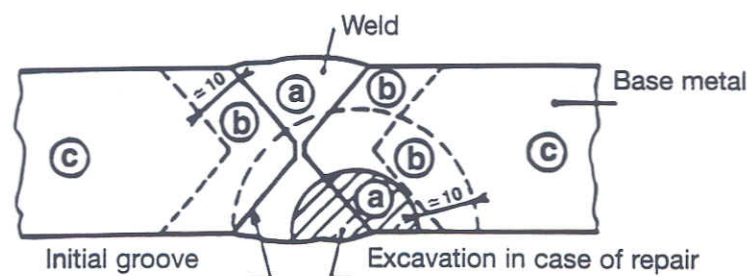
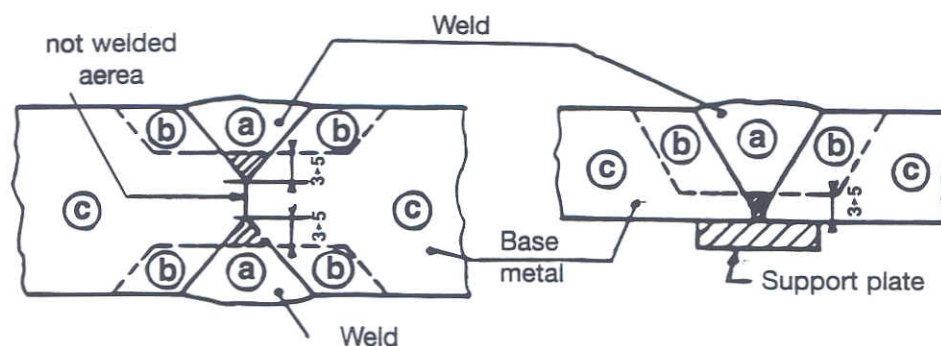


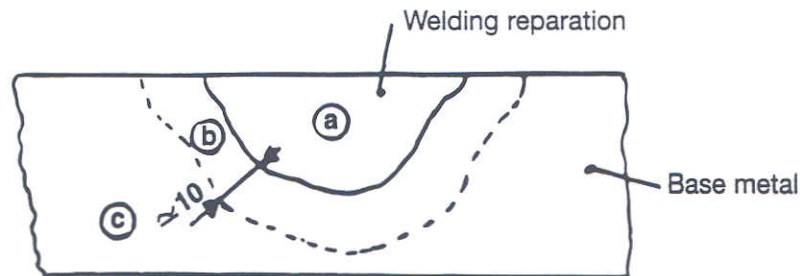
Figure 8 : Partial penetration weld or weld on supporting plate



Note for figures 7 and 8:

The hatched lined areas correspond to the area of doubt in view of the limits of the method.

Figure 9 : Weld repair



Legend :

Areas a + b : Application of welding acceptance criteria
Area c : Application of base metal acceptance criteria

2.4.2.2 Examples of pending welds or areas to be welded

The area subjected to inspection generally includes a 20 mm space relative to the edge of the groove (example figure 10) or to the area to be welded (example figure 11).

Figure 10 : Pending weld groove

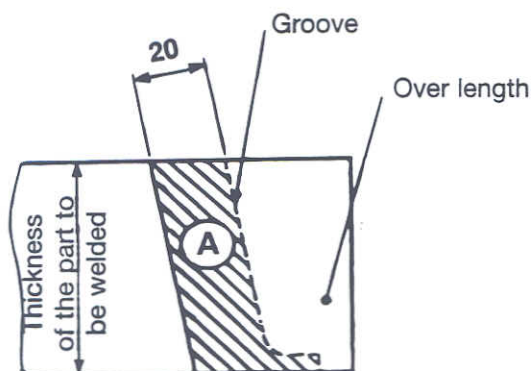
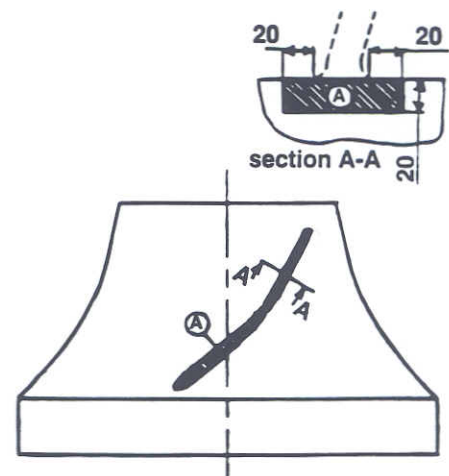


Figure 11 : Hub area to be welded



The extent of the inspection includes 100% of the volume of area A

2.4.3 SURFACE PREPARATION

The exploration surfaces must be free of any deposit, product, asperities which could hinder the transmission of waves or the free movement of the probe or which could provoke errors of interpretation (parasitic echoes). In cases of repair, the welds will be ground fine or machined. Unless otherwise specified, roughness Ra will not exceed 6.3 μm .

2.4.4 ADJUSTMENT OF THE SPEED OF SWEEP

The sweep range may be calibrated:

- either in distance over which to sweep,
- or in real depth of reflectors.

2.4.4.1 Adjustment of the distance swept

The adjustment is made using the fundamental steel calibration block IIW A2.

2.4.4.2 Adjustment of real depth of reflector

The adjustment is made from the artificial reflectors of the reference block indicated in § 2.3.5. The relative position of an echo on the screen allows to determine the real depth of the corresponding reflector.

2.4.5 ADJUSTMENT OF THE AMPLIFICATION AND THE INTENSITY

2.4.5.1 Use of reference block defined in § 2.3.5 (DAC method)

The adjustment of the amplification and the intensity is carried out from indications obtained from artificial reflectors (cylindrical holes in the reference blocks).

These adjustments are carried out simultaneously, the amplification threshold being brought back to the minimum. During these adjustments, the intensity must be maintained as low as possible.

The height adjustment of the reference echoes is obtained through the adjustment of the amplification.

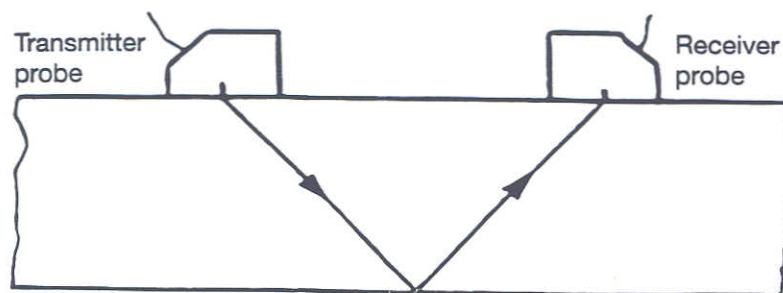
Correction for ultrasonic energy absorption

To consider to a certain extent possible differences in surface finish and/or absorption of ultrasonic waves between the casting under inspection and the reference block, the amplification will be modified as follows:

- Place the probe in an area of the casting which has parallel surfaces and whose thickness is equivalent to that of the block and whose surface finish and preferably whose internal structure is representative of the rest of the casting. This correction is made from the comparison of attenuations in the block and in the part over the same path of the ultrasonic beam, with the help of a transverse wave probe of the same type (dimensions and frequency) as those used for inspecting the part.

- Place two probes, one a transmitter and the other a receiver over the reference block as per figure 12. Note the gain necessary to bring the reception signal to an amplitude equal to 80% of the height of the screen. Without modifying the adjustments, the two probes are then placed over the part to be inspected. The difference in gain g_1 is translated by the increase in the gain necessary for the correction of ultrasonic energy absorption. The gain to use during the examination corresponds to the gain used to plot the distance amplitude curve plus the gain g_1 .
In practice this correction is carried out only if $g_1 > 2\text{dB}$.

Figure 12 : Correction for ultrasonic energy absorption



Adjustment from indications obtained from artificial reflectors on the reference block

Two methods of adjustment may be used :

a) Distance amplitude curve (DAC)

The principle to plot the distance amplitude curve is identical to that described for longitudinal waves (see paragraph 1.4.5 .1 a)

The maximum amplitude of the echoes obtained on cylindrical holes located at $1/4 T$ and $1/2 T$ from the same surface sounding and $3/4 T$ on the opposite surface is noted.

The curve linking these different points constitutes the distance amplitude curve. A fractioned distance amplitude curve is established when the amplitude of the echo obtained is less than 20% of the screen height. The same adjustment may be obtained using other types of reference blocks as described in paragraph 2.3.5.

b) When the apparatus so allows, **the adjustment of the sensitivity** is performed by taking note of **the amplitude values necessary** to bring the amplitude of the echoes on each reflector at the same height (approximately 80% of the height of the screen).

2.4.5.2 Use of existing reference diagrams defined in paragraph 2.3.6 (AVG method)

The method is identical to that of longitudinal waves (see § 1.4.5.2)

The acoustic absorption attributable to the material shouldn't be neglected and the method of correction of transfer described for the DAC method is applicable.

2.4.6 FREQUENCY OF VERIFICATION OF THE ADJUSTMENTS

The frequency of verification of the adjustments is identical to that defined in longitudinal waves (see § 1.4.6).

2.5 METHOD OF SURCHING FOR DEFECTS

The method should allow the investigation of the whole area to be inspected. The refraction angle of the ultrasonic beam is included between 70° and 45° . It will be a function of the thickness to be inspected, of the geometric shape of the casting or welded joint and of the type of indications to be determined.

The sweeping method over the area to inspect, the speed of shifting of the probe as well as sensitivity to the defects are identical to those defined for longitudinal waves (see § 1.5).

INDICATIONS TO BE INVESTIGATED.

2.5.1 EXAMPLE OF A WELDED JOINT BETWEEN TWO PARTS OR AN AREA REPAIRED BY WELDING

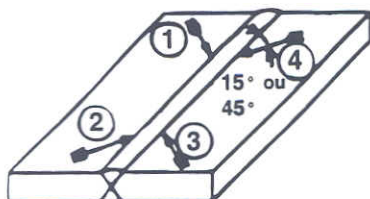
a) Detection of longitudinal indications

Longitudinal indications are those located in the same direction as the direction of welding. Two sounding angles with a difference of at least 10 to 15° between them shall be used.

b) Detection of transverse indications

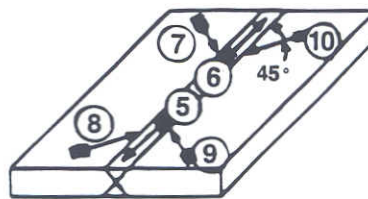
Transverse indications are those situated perpendicularly to the direction of welding. The indications will be detected in case of non machined welds with an angle of rotation of the probe relative to the direction of welding (see figure 13) and following two 180° directions for machined or ground welds (example figure 14).

Figure 13 : Non machined welds



Angle of rotation of the probe 15°
or 45° in case of ESW*
(Exploration direction 1, 2, 3 and 4)

Figure 14 : Machined welds



2 directions at 180° relative to the
probe (direction of exploration 5 and 6)
Note: In case of ESW*, the supplementary
angle of rotation of the probe is 45°
(supplementary exploration
direction 7, 8, 9 and 10)

*ESW: Electroslag Welding

2.5.2 EXAMPLE OF PENDING WELDS, AREAS TO BE WELDED, INDICATIONS TO BE CONFIRMED OR COMPLEMENTARY INVESTIGATIONS.

In all the areas to be inspected, the operator must carry out a complete sweep in all directions in order to find indications producing an echo.

Different types of angle probes will be used to obtain the maximum amplitude of the indication.

2.6 CHARACTERIZATION OF THE INDICATIONS

2.6.1 LOCATION

The location of the indications is identical to that defined for longitudinal waves (see § 1.6.1).

2.6.2 DIMENSIONING OF ECHOES OBTAINED BY THE INDICATIONS

2.6.2.1 Dimensioning in amplitude from the distance amplitude curve (DAC) obtained on the cylindrical holes

The dimensioning in amplitude is identical to that defined for longitudinal waves (see § 1.6.2.1).

2.6.2.2 Dimensioning in amplitude by the AVG method

The dimensioning in amplitude is identical to that defined for longitudinal waves (see § 1.6.2.2).

2.6.2.3 Dimensioning

a) Example of indications that are measurable in surface

The outline or the length of the defect is defined by the - 6 dB method as described for longitudinal waves (see § 1.6.2.3)

b) Example of indications that are non measurable in surface

The use of graph figure 4 of Euronorm CEN/TC 1 90 N 224: 1993 located in § 1.6.2.3 should be helpful.

2.6.3 CUMULATION OF INDICATIONS

a) Example of indications measurable in surface

The cumulation of two similar indications is identical to that defined for the longitudinal waves (see § 1.6.4).

b) Examples of indications whose length may be measured (cracks, lack of fusion ...)

• Single indication

Two indications seen through two different soundings (different angles or orientations) are considered obtained from the same reflector if the two following conditions are met :

- The distance separating the middle of their projections on the surface explored is less than 10% of the maximum depth.
- The distance between the middle of their projections over a cross section of the weld is 10% lower than the maximum depth

In these cases, the indication noted is characterized by the weakest depth and the most significant dimensions and amplitudes.

• **Separate indications**

Separate indications are cumulative if both of the following conditions exist :

- The distance which separates their projections on the surface explored is equal to or less than six times the length of the smallest projection or 20 mm if one of them is not measurable.
- The distance separating their projections over a cross section of the weld is equal to or less than 20 mm.

The amplitude of the cumulated indication is that of the most significant of the separate indications. Its dimension is obtained by joining the farthest extremities of both indications.

The rule of cumulation can only be applied to indications taken in isolation.

2.7 ACCEPTANCE CRITERIA

2.7.1 EXAMPLE OF A WELDED JOINT BETWEEN TWO PARTS OR AN AREA REPAIRED BY WELDING

The acceptance criteria are related to the characteristic of the defect, the height of the defect echo or the equivalent AVG diameter, their individual length and their cumulative length.

- Must be noted all the indications, the echo amplitude of which is $\geq 50\%$ of the amplitude of the reference echo.
- The indications producing an echo 20% superior to the reference echo will be analysed to determine their shape, their nature, their position and to assess them based on the following criteria :

a) Non volume defects

Indications viewed as defects such as cracks, lack of fusion, incomplete penetration are considered unacceptable regardless of their length or amplitude.

b) Volume defects

Defects are unacceptable if their amplitude exceeds the reference level and if their length exceeds the following dimensions:

Length = 6 mm per $t \leq 19$ mm

Length = $t/3$ for t included between 10 and 57 mm

Length = 19 mm for $t > 57$ mm

t is the thickness of the weld or the depth of excavation.

For welds joining 2 elements of different thicknesses « t » is the smallest of the two thicknesses.

2.7.2 EXAMPLES OF PENDING WELDS, OF AREAS TO WELD OR OF COMPLEMENTARY INVESTIGATIONS

The acceptance criteria are based on the characterization of the defect, the height of the defect echo, the equivalent AVG diameter, the number of non measurable indications, the surface of each basic zone, the cumulated surface and length of the basic zones.

- All indications, the amplitude echo of which is ≥ 50 % of the reference echo must be noted.
- The indications producing an echo > 20 % of the reference echo will be analysed to determine their shape, their nature, their position and to assess them, based on the following criteria :

a) Non volume defects

Linear discontinuities, hot cracks, shrinkage cavities are considered unacceptable regardless of their length and their amplitude.

b) Volume defects

Defects are unacceptable if their amplitude exceeds the reference level and if the number of non measurable indications or surface measurable indications, exceed respectively the set values in tables 4 and 5 defined in § 1.7 «CRITERIA OF ACCEPTANCE» for longitudinal waves.

Note :

This note is applicable to § 2.7.1 et 2.7.2 :

Indications below the notation threshold: Individual amplitude indications inferior to the notation threshold aren't considered as significant of defects requiring repair. However, at the Designer's request, they are the subject of additional analysis so as to determine their nature, if these defects are continuous or repetitive or if their position is critical.

2.8 INSPECTION REPORT

The inspection report must indicate the same informations as that defined in § 1.10 «Longitudinal waves examination».

TECHNICAL SPECIFICATION FOR RADIOGRAPHIC INSPECTION

1 - OBJECTIVE AND FIELD OF APPLICATION

The radiographic inspection is intended for the detection of potential internal defects within a given casting, welded areas (construction and/or repair). It allows as well to identify with accuracy the nature and the dimensions of defects already revealed by, for example, an ultrasonic inspection. It may therefore be considered as a method of exclusive investigation to determine the quality of a casting, and as a complementary process of the ultrasonic tests (see «Introduction» paragraph 4).

This inspection method can generally be carried out on all castings. Only the thickness, the shape of the parts and accessibility can limit the use of this technique.

2 - GENERAL

The present specification, except for special cases, is based on the technique of double films.
The Designer could request a specific procedure for the radiographic inspection of certain parts.

3 - SURFACE PREPARATION

The surface inspected should be free of any anomaly which could interfere with the interpretation of the films. It is performed after a quality heat treatment and before stress relieving (see GE 70-3, paragraph 1.4).

4 - SOURCES

Taking into consideration the thickness of the metal to be radiographed, the shape of the part and the specific requirement imposed, X or γ rays will be used to obtain the best quality image so as to correctly perform the radiographic examination.

Table 1

Guide for the use of radiographic sources based on the thickness of metal to be inspected

source	Xrays 100 à 400 KV	γ rays Ir 192	γ rays Co 60	Xrays 1 to 4 Mev	Xrays 4 to 12 Mev
Thickness	≤ 50 mm	10 to 90 mm	40 to 200 mm	60 to 200 mm	≥ 80 mm

5 - RADIOGRAPHIC FILMS

The types of film will be chosen according to the types of defect sought and the areas to be inspected. The table below may serve as a guide for choosing film types.

5.1 TYPES OF RADIOGRAPHIC FILMS

Table 2
Types of films

Class of film according to :				Properties	Sensitivity
EN 584 part 1	NF 09-211	DIN 54111 §1	ASTM	NF 09-211	NF 09-211
C1	I	G1	I	Very fine grain	Exceptionnal
C2-C3	II	G2	I	Fine grain	Very good
C3	III	G2	II	Fine grain	Good
C4	III - IV	G2	II	Fine grain	Good
C5	V	G3	III	Medium grain	Average
C6	-	G4	IV	Thick grain	Weak

5.2 GUIDE FOR CHOOSING FILM

Table 3
Choosing film

Radiographic areas	Types of films to use
Areas to be welded	Up to type C3
Castings of ≤ 200 mm Part of a casting > 200 and < 400 mm in thickness Part of a casting > 400 mm	Up to type C4 Up to type C5 Up to type C6
Part of a component repaired by welding of ≤ 200 mm in thickness Part of a component repaired by welding and of > 200 et < 400 mm in thickness	Up to type C3 Up to type C4

6 - INTENSIFYING SCREENS, FILTERS, BACK-SCATTER PROTECTION.

The screens should be perfectly smooth and clean and free of any scratches.

In general, intensifying screens are made of lead. Others materials such as stainless steel or tantalum could be used by proving their efficiency.

The use of fluorescent screens is prohibited.

6.1 INTENSIFYING SCREENS

Table 4
Guide for choosing intensifying screens

Radiation type	Previous screen thickness in mm	Intermediate screen thickness in mm	Posterior screen thickness in mm
X ray < 100 KV	0,03 maxi - lead	0,03 maxi - lead	0,03 maxi - lead
X ray of 100 to 150 KV	0,15 maxi - lead	0,10 maxi - lead	0,15 maxi - lead
X ray of 151 to 250 KV	0,02 to 0,15 - lead	0,02 to 0,15 - lead	0,02 to 0,15 - lead
X ray of 251 to 500 KV	0,02 to 0,2 - lead	0,02 to 0,15 - lead	0,02 to 0,2 - lead
Ir 192	0,02 to 0,2 - lead	0,02 to 0,15 - lead	0,02 to 0,2 - lead
Co 60	0,25 to 0,7 - lead	0,1 to 0,15 - lead	0,25 to 0,7 - lead
X ray of 1 to < 4 Mev	0,25 to 0,7 - steel ⁽¹⁾	0,1 to 0,2 steel ⁽¹⁾	0,25 to 0,7 - steel ⁽¹⁾
X ray of 4 to 12 Mev	1,0 maxi - steel or tantalum ⁽²⁾	0,1 to 0,2 steel or tantalum ⁽²⁾	1,0 maxi - steel or tantalum ⁽²⁾
X ray of > 12 Mev or less	1,0 maxi - tantalum ⁽²⁾	0,1 to 0,2 - tantalum ⁽²⁾	0,5 maxi - tantalum ⁽²⁾

⁽¹⁾ Lead screen of 0,1 to 0,5 mm of thickness may be used

⁽²⁾ Lead screen of 0,5 to 1,0 mm of thickness may be used

6.2 FILTERS

The use of filters is not compulsory for the inspection of castings. It is however recommended for inspection of weld preparations, or welds, or the inspection of repaired parts. Filters are not required for X-ray inspections (≥ 3 MeV).

Table 5
Recommended thickness for lead filters

Thickness of filter to be used in mm	Thickness to be inspected
0,3 to 0,5	≤ 50 mm
0,5 to 1	$50 < \text{thickness} \leq 70$ mm
1 to 1,5	$70 < \text{thickness} \leq 110$ mm
1,5 to 2	thickness > 110 mm

6.3 BACK-SCATTER PROTECTION (CUTOFFS)

Cutoffs are used to intercept backscatter rays. They are compulsory and are made of one or several sheets of lead of a minimum of :

- 1 mm in thickness in the case of the use of an Ir or Co source and of
- 5 mm for X-ray (≥ 3 Mev).

The cutoffs are placed directly behind the cartridge.

It may be required to demonstrate through the application of 1,5 mm letter « B » in lead placed behind the film, that the radiation applied doesn't leave an imprint of this letter on the film. This letter is placed between the film and the cutoff.

7 - IDENTIFICATION OF FILMS

7.1 LOCATION MARKERS

Location markers should be placed on each area to be inspected, if possible on the source side, in such a way that at least two markers are visible on each film.

Their exact location should be marked on the surface thus permitting exact repositioning of the film.

The geometry of the casting may be taken advantage of (tin of splitter edge, outlet edge, ...) if they permit exact repositioning of the film.

7.2 IDENTIFICATION

Each film shall be marked in such a way that it can be identified permanently in accordance with the shooting sketch.

8 - IMAGE QUALITY INDICATOR.

The image quality indicators (IQI of tables 6 and 7) are placed perpendicular to the beam of radiation, wherever possible on the source side of the casting. They will be placed if possible outside the interpretation zone of the film. In case of large thickness variation, an IQI will be placed in the weakest area and another IQI will be placed in the thickest area.

9 - SOURCE-FILM DISTANCE (FOCUS-FILM DISTANCE)

Except for specific cases the source-film distance should permit to respect the geometric unsharpness defined in paragraph 9.2.

9.1 GEOMETRICAL UNSHARPNESS

The geometrical unsharpness (U_g) is determined using the formula :

$$U_g = \frac{d \cdot e}{D - e} \text{ (expressed in mm)}$$

e = distance between the source side face and the film (inspected thickness)

D = source-film distance in mm

d = dimension of the source face turned towards the film side.

9.2 UNSHARPNESS TO BE TAKEN INTO ACCOUNT

The unsharpness should be inferior to:

- 0,5 mm for $e \leq 50$ mm
- 0,7 mm for $50 < e \leq 100$ mm
- 1,0 mm for $100 < e \leq 150$ mm
- 1,5 mm for $e > 150$ mm

In the case of X-ray generator (≥ 3 Mev) the distance focus-part will be at least 1500 mm.

10 - QUALITY OF RADIOGRAPHS

Different values of the following parameters may be accepted case by case with the approval of the Designer.

The radiographic films should not present indications such as marks of screens, traces of development or veil, which may mask the defects in the zone to interpret.

10.1 IMAGE QUALITY

Image quality will be evaluated by identification of the smallest visible hole or wire depending on the thickness being radiographed. The last visible hole or wire of the IQI will be that described in the tables below.

Table 6 :
IQI acceptability limits for control castings

IQI AFNOR			IQI DIN 54109			IQI ASTM (hole)		
Thickness to be inspected in mm	Hole Ø in mm	type	Thickness to be inspected in mm	Wire Ø in mm	type	Thickness to be inspected in mm	IQI n°	level
10 to 16	0,63	HA	10 to 16	0,32	11	6,3	5	2-2T
16 to 25	0,80	HA/HB	16 to 25	0,40	10	12,7	10	2-2T
25 to 32	1,0	HB	25 to 32	0,50	9	15,24	12	2-2T
32 to 40	1,25	HB	32 to 40	0,63	8	19,05	15	2-2T
40 to 80	1,60	HB	40 to 60	0,80	7	21,59	17	2-2T
80 to 100	2,0	C/HB	60 to 80	1,0	6	25,4	20	2-2T
100 to 150	2,5	C/HB	80 to 150	1,25	5	38,1	30 ⁽¹⁾	2-2T
150 to 200	3,2	C	150 to 170	1,6	4	50,8	40	2-2T
200 to 250	4,0	C	170 to 180	2,0	3	63,5	50	2-2T
250 to 320	5,0	C	180 to 190	2,5	2	76,2	60 ⁽²⁾	2-2T
320 to 400	6,3	C	190 to 250	3,2	1	101,6	80	2-2T
			250 to 320	4,0		127	100	2-2T
			320 to 400	5,0		152,4	120 ⁽³⁾	2-2T
						191	150	2-2T
						203,2	160	2-2T
						228	180	2-2T
						254	200	2-2T
						381	300	2-2T

(1) Between IQI n°20 and 50, intermediate values from 5 to 5 are possible

(2) Between IQI n°50 and 100, intermediate values from 10 to 10 are possible

(3) As of IQI n° 120, intermediate values from 20 to 20 are possible

Table 7 :
IQI acceptability limits for control of welds

IQI AFNOR			IQI DIN 54109			IQI ASTM (hole)		
Thickness to be inspected in mm	Hole Ø in mm	type	Thickness to be inspected in mm	Wire Ø in mm	type	Thickness to be inspected in mm	IQI n°	level
10 to 16	0,50	HA	10 to 16	0,25	11	6,3	5	2-2T
16 to 25	0,63	HA	16 to 25	0,32	10	12,7	10	2-2T
25 to 32	0,80	HA/HB	25 to 32	0,40	9	15,24	12	2-2T
32 to 40	1,0	HA/HB	32 to 40	0,50	8	19,05	15	2-2T
40 to 80	1,25	HB	40 to 60	0,63	7	21,59	17	2-2T
80 to 100	1,60	HB	60 to 80	0,80	6	25,4	20	2-2T
100 to 150	2,0	C/HB	80 to 150	1,0	5	38,1	30 ⁽¹⁾	2-2T
150 to 200	2,5	HB/C	150 to 170	1,25	4	50,8	40	2-2T
200 to 250	3,2	C	170 to 180	1,6	3	63,5	50	2-2T
250 to 320	4,0	C	180 to 190	2,0	2	76,2	60 ⁽²⁾	2-2T
320 to 400	5,0	C	190 to 250	2,5	1	101,6	80	2-2T
			250 to 320	3,2		127	100	2-2T
			320 to 400	4,0		152,4	120 ⁽³⁾	2-2T
						191	150	2-2T
						203,2	160	2-2T
						228	180	2-2T
						254	200	2-2T
						381	300	2-2T

In case of use of IQI wires of the ASTM standard, the level of quality obtained will have to correspond to that of the IQI with holes of this same standard. Other types of IQI could also be used. In general, one should attempt to obtain sensitivity equal to 2 % for the inspection of the castings and 1,5 % for the welds according to the formula :

$$S \% = \frac{\text{diameter of the smallest visible hole or wire} \times 100}{\text{thickness}}$$

10.2 DENSITY

The density of the exposed single or double films should be comprised between 2,0 and 4 with a min. of 1.3 per single film. The density may reach a reading of 4.5 if the illuminator allows.

Density will be checked by means of a densitometer or by comparison with reference films. In case of great variation of thickness, the density could be determined on films of a different speed. Interpretation will be determined either in double or single film with the possibility of mixing films of different speeds while remaining in double film at a maximum.

10.3 DEVELOPMENT

Film development may be made manually or using an automatic machine. The film development will be completed according to the manufacturer's instructions.

Precautions should be taken to obtain a good fixing and a good washing of films to allow for proper conservation. Unless otherwise indicated, the films will be kept by the Company in charge of their development in a way to be able to interpret them. The Designer will specify at time of ordering the duration of archiving.

11 - ACCEPTANCE CRITERIA

The levels of acceptance may be different depending on the zones inspected (castings, highly stressed areas, repaired or assembled parts by welding).

11.1 FOR CASTINGS :

The films will be compared to reference films of the ASTM standard, corresponding to the controlled thickness and to the source used.

These **ASTM reference negatives** are:

- for thicknesses of less than 51 mm : standard E-446
- for thicknesses included between 52 and 114 mm : standard E-186
- for thicknesses included between 114 and 305 mm : standard E-280
- for thicknesses greater than 305 mm, the standard E-280 will be used unless specified otherwise.

The defects on these standards are identified by a letter, namely:

- type A indications : gas porosity
 - type B indications : sand and slag inclusion
 - type C indications : shrinkage
 - type D indications : crack
 - type E indications : hot tear
 - type F indications : insert
- Example: «C3» corresponds to a class 3 shrinkage

For interpretation, one needs to determine the nature of the defect first, then compare the size and the density of the indications with those of the reference film of this standard, for a surface corresponding to the reference surface of the standard.

Table 8 :
Admissible defects based on classes of acceptance

Type of indications	ASTM Symbol	Thickness considered	Reference	Level of severity as per ASTM class				
				1	2	3	4	5
Gas porosity	A	≤ 50	E 446	A1	A2	A3	A4	A5
		>50 à ≤114	E 186	A1	A2	A3	A4	A5
		>114 à ≤305	E 280	A1	A2	A3	A4	A5
Sand and slag inclusion	B	≤ 50	E 446	B1	B2	B3	B4	B5
		>50 à ≤114	E 186	B1	B2	B3	B4	B5
		>114 à ≤305	E 280	B1	B2	B3	B4	B5
Shrinkage	C	≤ 50	E 446	Ca1, Cb1 Cc1, Cd1	Ca2, Cb2 Cc2, Cd2	Ca3, Cb3 Cc3, Cd3	Ca4, Cb4 Cc4, Cd4	Ca5, Cb5
		>50 à ≤114	E 186	Ca1, Cb1, Cc1	Ca2, Cb2, Cc2	Ca3, Cb3, Cc3	Ca4, Cb4, Cc4	Ca5, Cb5
		>114 à ≤305	E 280	—	Ca2, Cb2, Cc2	Ca3, Cb3, Cc3	Ca4, Cb4, Cc4	Ca5, Cb5
Hot tear	D + E							D1, E1 (1)
Inacceptable								
Inserts	F	≤ 50	E 446				F1 (2)	F1
		>50 à ≤114	E 186				F1 (2)	F1
		>114 à ≤305	E 280				F1 (2)	F1

(1) Cracks are authorised with maxi length : 7 mm for thickness < 10 mm
2/3 of the thickness for thickness > 10 and < 100 mm
100 mm for thickness > 150 mm

(2) Core supports may be present, but they must be bonded to the metal without crack at the surface of the part

Table 9 :
Limits of acceptance (according to ASME section VIII)

l : width of the indication

The films on repairs will be identified by the letter R in addition to the identification already mentioned. The defects that are outside these criteria will be eliminated by grinding or gouging. They will be inspected again after repair.

Unless otherwise specified, the weld repairs will be examined according to the criteria defined in §11.1.

12 - INSPECTION REPORT

The inspection report must indicate:

- Identification of the Founder, the Manufacturer or the Designer.
- Identification of the part (heat Nr., traceability).
- Steel grade of the casting.
- Designation of the examination documents used: Reference to the present specification, Quality Sheet.
- Stage of manufacture at inspection.
- Mode of surface preparation.
- Designation of films, source, IQI, screens.
- Examination conditions.
- Areas inspected.
- Inspection results.
- Name of the inspector, his signature and his certification.
- Identification of the firm in charge of the inspection, if sub-contracted.
- Date of inspection and signature of the responsible person for inspection.